AL.2.2003.267
University of Alberta Library
0 1620 3682114 6

SCIENCE 8

MODULE 1

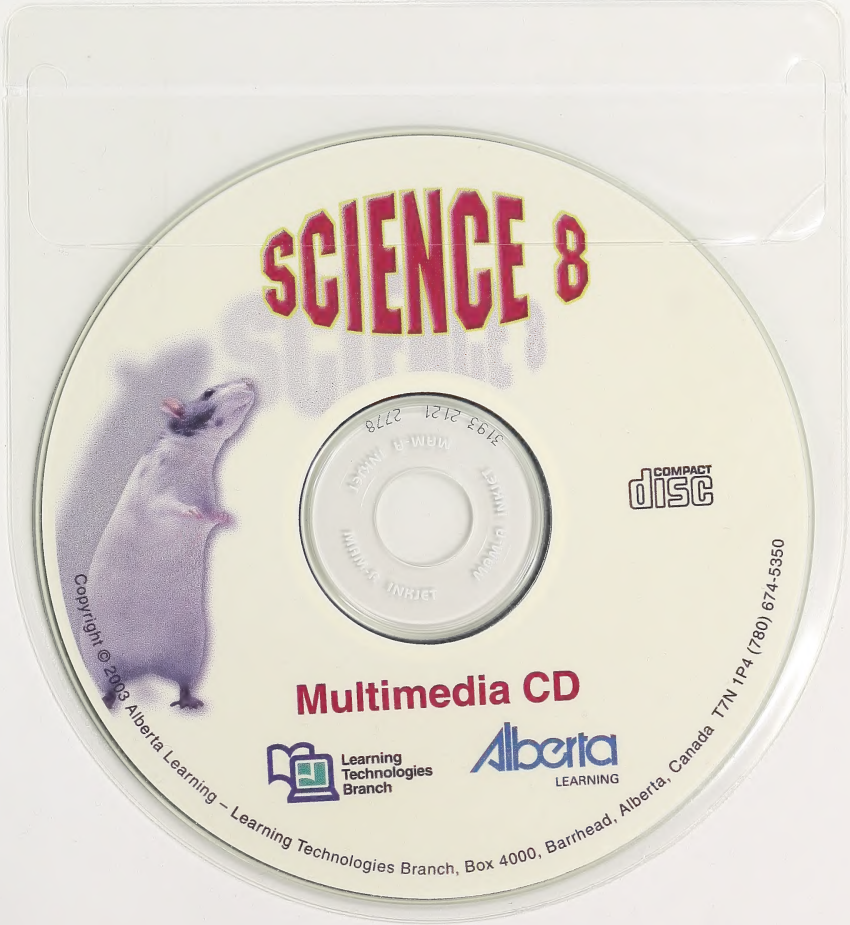
MIX AND FLOW OF MATTER

Learning Technologies Branch

Alberta LEARNING

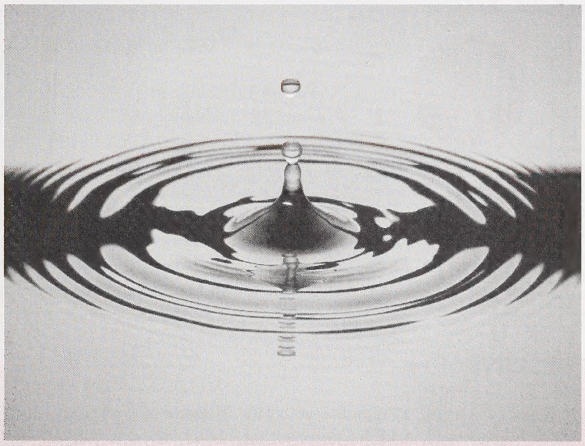
Digitized by the Internet Archive
in 2016 with funding from
University of Alberta Libraries

https://archive.org/details/science801albe


SCIENCE 8
COMPACT disc
Multimedia CD
Learning Technologies Branch
Alberta LEARNING
Copyright © 2003 Alberta Learning – Learning Technologies Branch, Box 4000, Barrhead, Alberta, Canada T7N 1P4 (780) 674-5350

SCIENCE 8

MIX AND FLOW OF MATTER 1



Learning Technologies Branch

Alberta LEARNING

Science 8
Module 1: Mix and Flow of Matter
Student Module Booklet
Learning Technologies Branch
ISBN 0-7741-2364-8

The Learning Technologies Branch acknowledges with appreciation the Alberta Distance Learning Centre and Pembina Hills Regional Division No. 7 for their review of this Student Module Booklet.

This document is intended for	
Students	✓
Teachers	✓
Administrators	
Home Instructors	
General Public	
Other	

You may find the following Internet sites useful:

- Alberta Learning, **http://www.learning.gov.ab.ca**
- Learning Technologies Branch, **http://www.learning.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.learning.gov.ab.ca**

The use of the Internet is optional. Exploring the electronic information superhighway can be educational and entertaining. However, be aware that these computer networks are not censored. Students may unintentionally or purposely find articles on the Internet that may be offensive or inappropriate. As well, the sources of information are not always cited and the content may not be accurate. Therefore, students may wish to confirm facts with a second source.

ALL RIGHTS RESERVED

Copyright © 2003, the Crown in Right of Alberta, as represented by the Minister of Learning, Alberta Learning, 10155 – 102 Street, Edmonton, Alberta T5J 4L5. All rights reserved. Additional copies may be obtained from the Learning Resources Centre.

No part of this courseware may be reproduced in any form, including photocopying (unless otherwise indicated), without the written permission of Alberta Learning.

Every effort has been made both to provide proper acknowledgement of the original source and to comply with copyright law. If cases are identified where this effort has been unsuccessful, please notify Alberta Learning so that appropriate corrective action can be taken.

IT IS STRICTLY PROHIBITED TO COPY ANY PART OF THESE MATERIALS UNDER THE TERMS OF A LICENCE FROM A COLLECTIVE OR A LICENSING BODY.

UNIVERSITY LIBRARY
UNIVERSITY OF ALBERTA

WELCOME

MODULE 1 Mix and Flow of Matter

MODULE 2 Cells and Systems

MODULE 3 Light and Optical Systems

MODULE 4 Mechanical Systems

MODULE 5 Freshwater and Saltwater Systems

Contents

Resources 6

Before You Begin 6

Icons 7

Overview 8

- Assessment 9
- Planning Ahead 10

Section 1: The Particle Model and Solutions 11

Lesson 1: Matter on the Move 12

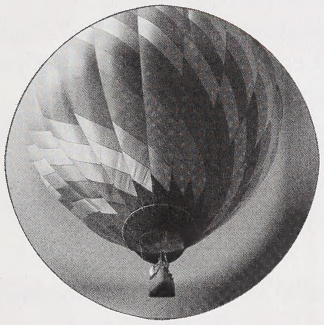
Lesson 2: Mixing and Dissolving 15

Lesson 3: Separating Earth's Mixtures 24

Section Review 29

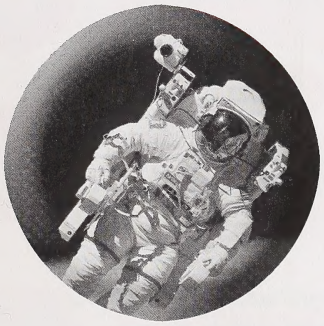
Conclusion 30

Section 2: Properties of Fluids 31



Lesson 1: Flow Rate and Viscosity 32
Lesson 2: Density 47
Lesson 3: Buoyancy 53
Section Review 64
Conclusion 65

Section 3: Working with Fluid Pressure 66



Lesson 1: Fluid Pressure 67
Lesson 2: Fluid Systems 76
Section Review 81
Conclusion 81

Summary 83

Module Review 84

Appendix 85

Glossary 86
Suggested Answers 89
Image Credits 100

Resources

Textbook

To complete the course, you need the textbook *ScienceFocus 8*.

Multimedia

Attached to Module 1 of this course is a CD titled *Science 8 Multimedia*. This CD contains multimedia segments designed to help you better understand particular concepts presented in this course. Ask your teacher or home instructor if you need help using this CD.

Materials and Apparatus

A list of materials and apparatus is given on page 10 of each Student Module Booklet. These items are needed to complete the module. Some of the materials and apparatus may be provided at your local school lab. If you don't have access to a school lab, you will need to get the loan kit. Talk to your teacher for more information.

Before You Begin

Organize your materials and work area before you begin: Student Module Booklet, textbook, notebook, pens, pencils, and so on. Make sure you have a quiet area in which to work, away from distractions.

Because response lines are not provided in the Student Module Booklet, you'll need a looseleaf binder or notebook to respond to questions and complete charts. It's important to keep your lined paper handy as you work through the material and to keep your responses together in a notebook or binder for review purposes later.

Refer to the Planning Ahead page for directions on what you need to do before you start this module.

Good luck!

Icons

This is one of five Student Module Booklets for Science 8. As you progress through this module, you will meet several icons.

Do Ahead

Some preparation must be started well ahead of the activity or investigation. E.g., start the seedlings for the investigation in Lesson 3.

Teacher or Home Instructor

The teacher or home instructor should be contacted for help, approval of some procedure, or checking answers.

Assignment Booklet

Work needs to be done in an Assignment Booklet.

Safety

You must be very careful when you see this symbol.

Textbook

A reference is made to *ScienceFocus 8*, the student textbook for this distance learning course.

Internet

This is a reference to the Internet. **Note:** Any Internet website given is subject to change.

Multimedia

This is a reference to the *Science 8 Multimedia* CD.

Overview

Life as you know it would not exist were it not for fluids. You play, float, bathe, and move in fluids. You breathe and drink fluids and depend on fluids to transport nutrients and waste products throughout your body. Plants and animals also depend on fluids to sustain life. Technologies such as bicycle tires, airbags in automobiles, hot-air balloons, fire extinguishers, and aerosol products are all applications of fluids and their properties. Also think of water pistols and hydraulic lifts; these are mechanical devices that use fluids to do work.

Section 1
The Particle Model and Solutions

Section 2
Properties of Fluids

Section 3
Working with Fluid Pressure

In this module you will explore why the properties of fluids are so important to people's lives.

Assessment

The booklet you are presently reading is the Student Module Booklet. It will show you, step by step, how to advance through Module 1: Mix and Flow of Matter.

This module, Mix and Flow of Matter, has three sections. Within each section your work is grouped into lessons. Within the lessons there are readings, investigations, activities, and questions for you to do. By completing these lessons you will discover scientific concepts and skills, develop a positive attitude toward science, and practise or apply what you have learned.

Suggested answers in the Appendix of this Student Module Booklet will provide you with immediate feedback on the answers to questions in the lesson. Your teacher or home instructor will also provide you with feedback on your progress through the module.

At several points in this module you will be directed to an accompanying Assignment Booklet. Your grading in this module is based on the assignments you submit for assessment. In this module you are expected to complete three section assignments and a Final Module Assignment.

The mark distribution is as follows:

Assignment Booklet 1A	
Section 1 Assignment	34 marks
Assignment Booklet 1B	
Section 2 Assignment	50 marks
Assignment Booklet 1C	
Section 3 Assignment	20 marks
Final Module Assignment	32 marks
TOTAL	136 marks

Planning Ahead

Here is a list of materials and apparatus you will need to complete this module.

Section 1

- ❑ a 100-mL graduated cylinder
- ❑ two beakers or kitchen measuring cups
- ❑ two clear containers (about 400-mL capacity)
- ❑ two large plates
- ❑ four containers or labels with WHMIS or HHPS symbols
- ❑ a magnifying glass
- ❑ baking soda
- ❑ cereal, jam, milk, orange juice, salsa, soap, toothpaste, or similar household mixtures
- ❑ a funnel
- ❑ a measuring cup
- ❑ a pair of scissors
- ❑ latex gloves
- ❑ a ruler
- ❑ safety goggles
- ❑ sand
- ❑ a scientific filter paper disc or disc cut out from a coffee filter
- ❑ small beakers or water glasses
- ❑ sugar
- ❑ table salt
- ❑ a 15-mL measuring spoon or a tablespoon

Section 2

- ❑ a 100-mL graduated cylinder
- ❑ 15-mL samples of any three of these: water; liquid detergent; honey; molasses; vegetable oil; corn syrup
- ❑ a 1-L plastic pop bottle & cap
- ❑ two 200-mL water glasses
- ❑ two waterproof objects—one that sinks and one that floats
- ❑ adhesive tape
- ❑ a cake pan
- ❑ a cork
- ❑ a flat sheet of plastic (at least 50 cm by 30 cm)
- ❑ food colouring
- ❑ a medicine dropper
- ❑ paper clips
- ❑ a pitcher or a large measuring cup with a spout
- ❑ latex gloves
- ❑ safety goggles
- ❑ several light-weight plastic bags with locking seals
- ❑ soap and paper towels
- ❑ a 10-N spring scale
- ❑ a stack of books
- ❑ a stopwatch or watch with a second hand
- ❑ a 15-mL measuring spoon
- ❑ a thermometer
- ❑ a toothpick or a wood chip
- ❑ graph paper
- ❑ a waterproof, felt-tip pen
- ❑ a wide-mouthed transparent jar with a screw-on lid

Section 3

- ❑ a 100-mL graduated cylinder
- ❑ two empty balloons
- ❑ two modified syringes—different sizes, one with a tip cap
- ❑ a beaker or a water glass
- ❑ duct tape or other adhesive tape
- ❑ a hook or a thumbtack
- ❑ a large screwdriver
- ❑ a metre-stick or a 1-m length of dowel
- ❑ one sandwich bag
- ❑ one wide-mouthed jar, such as a 2-L peanut-butter jar
- ❑ a pair of scissors
- ❑ latex gloves
- ❑ a ruler or a tape measure
- ❑ safety goggles
- ❑ a sharp pin
- ❑ a short piece of plastic tubing
- ❑ string
- ❑ two elastic bands
- ❑ a plastic bottle with a narrow spout
- ❑ a pail

If you have access to the Internet, you may want to check out some of the links for this module ahead of time. Go to the following site:

http://www.mcgrawhill.ca/school/booksites/sciencefocus+8/student+resources/toc/index.php

Section 1

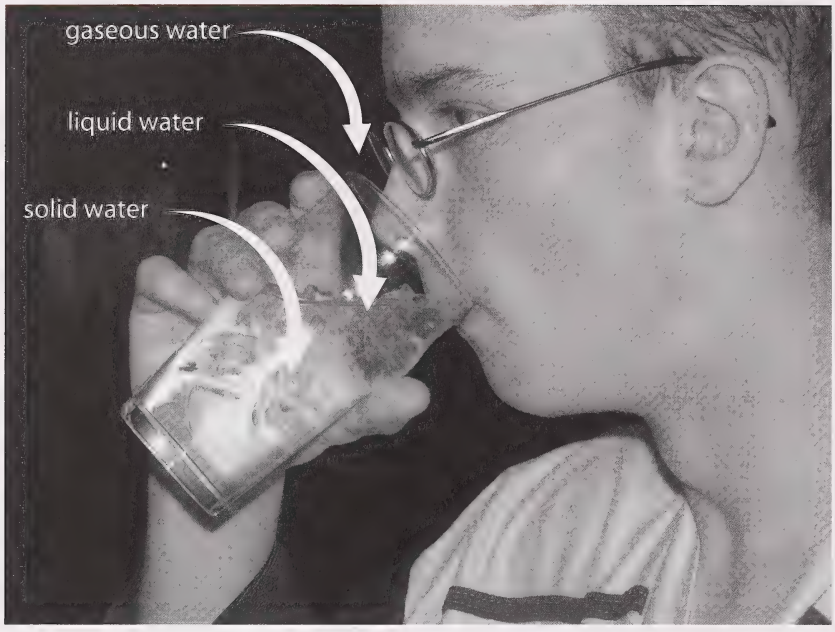
The Particle Model and Solutions

Going out with some friends for an ice-cream sundae is a good time. A sundae is a wonderful treat. Now think about other items, such as lemonade, hair gel, and air.

What do all these substances have in common? All are mixtures that are composed of tiny bits of matter called particles. The particles are so small that they are invisible.

In this section you will explore how to use the particle model of matter to explain the classification of gases and liquids as fluids, why they flow, and how they are different from solids. You will investigate how matter is classified into pure substances and mixtures. You will also investigate the role of fluids in forming and separating mixtures.

Lesson 1: Matter on the Move



gas: a state of matter having neither a definite shape nor a definite volume; an airlike form

liquid: a state of matter having a definite volume but not a definite shape

solid: a state of matter having a definite shape and a definite volume, such as a brick

fluid: a substance that can flow

Liquids and gases are fluids.

How can you explain the existence of matter in the three states of **gas**, **liquid**, and **solid**? Why does a substance change from one state to another? Answering these questions is the topic of this lesson.

In this lesson, and in the rest of this course, you will be doing written work. You will sometimes be directed to an Assignment Booklet to do this written work. However, for the numbered questions in Student Module Booklets, you should answer the questions in a notebook set aside for Science 8.

I write my answers in my notebook. There's lots of room there.

Also, use the notebook to record results while doing science investigations.

Both liquids and gases are **fluids**. Fluids flow. The behaviour of a substance provides a good clue about the state of a substance. But its behaviour can fool you—as you will see in the next activity about salt.

To help you distinguish between a solid and a fluid, carry out the next activity.

Find Out Activity: Can Solids Flow?

Do the activity on page 6 of the textbook.

You may modify the steps of "Procedure" by using a kitchen measuring cup instead of beakers.

Keep the salt. You will need salt in the next lesson.

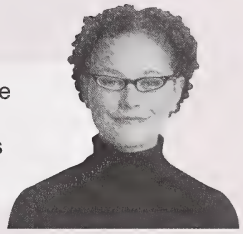
1. Answer questions 1 and 2 of "What Did You Find Out?"

Check your answers with your teacher or home instructor.

Going Further

Playing and creating are two fun ways to learn. Put the two together for the project at the end of this textbook unit. Read pages 4 and 5 of the textbook. Get started with "Looking Ahead."

These "Going Further" sections are for those of you who want to do extra in-depth work. There are lots of interesting topics to work on.



The Particle Model of Matter

Madurodam is a miniature city built in The Hague. It contains scale models of many famous buildings found throughout the Netherlands.

A model is a representation of something else. In Madurodam the models are physical. Scientists use models to help explain observations or to simplify descriptions of abstract ideas. The particle model of **matter** is a scientific model.

matter: *anything that has mass and occupies space*

With the particle model of matter, scientists explain the existence of matter in the three states and describe the properties and behaviour of gases, liquids, and solids.

Read pages 7 to 10 in the textbook to find out how the particle model of matter explains these behaviours and properties.

Complete the following questions in your notebook.

2. Classify each of the following substances as a gas, a liquid, or a solid.

a. a substance having a definite shape and a definite volume
b. a substance having an indefinite shape and an indefinite volume
c. a substance having an indefinite shape and a definite volume

3. Using the particle model of matter, explain in your own words why gases and liquids flow, while solids do not.

Check your answers with your teacher or home instructor.

Changes of State

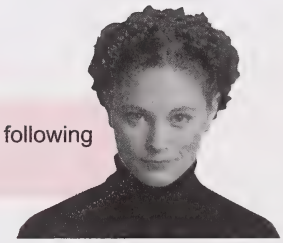
Suppose you add energy to particles of a substance. You can add energy by heating the substance. This will cause the particles to move faster, hit each other harder, and separate from each other. As the space between particles increases, forces between particles could weaken enough so that particles escape. Particles that escape from a solid or liquid experience a change of state.

sublimate: to change from a solid to a gas or from a gas to a solid without becoming a liquid

If you add enough energy to a substance in a solid state, it will become a liquid and then a gas. Remove enough energy from a gas and the opposite occurs. Under certain conditions a substance will **sublimate**—it may "skip" a state.

Read pages 11 and 12 of the textbook to find what conditions are needed for a substance to change its state.

Remember to complete the following questions in your notebook.



4. Use the particle model of matter to explain a change of state in a substance.

5. Dry ice is used at a rock concert to produce fog for special effects. What is the proper term for the change in state of dry ice?

6. To test your understanding of the concepts in this lesson, answer questions 1 to 5 of "Topic 1 Review" on page 12 of the textbook.

Check your answers with your teacher or home instructor.

Looking Back

In this lesson you studied the properties of fluids.

Turn to Assignment Booklet 1A. Complete question 1 from Section 1.

Lesson 2: Mixing and Dissolving

Raja helped to put away purchases after shopping with his family. Before putting things away he looked at some labels. He saw that many of the things the family uses, such as bleach, nail polish, vinegar, and soft drinks, consist of more than one ingredient. For sugar there was only one thing listed as an ingredient. Raja wondered whether a label showing one ingredient was a sign that the container held a **pure substance** and whether a label showing more than one ingredient was an indication of a **mixture**.

pure substance: matter that consists of only one kind of particle

mixture: matter that consists of two or more substances

In this lesson you will study how to classify matter into pure substances and mixtures. You will also discover the difference between two kinds of mixtures—homogeneous mixtures are also known as solutions, while mechanical mixtures can also be referred to as heterogeneous mixtures. Then you will investigate what processes and properties of substances affect how mixtures are formed.

Classifying Matter

property: a characteristic that can be used to identify or describe a substance

To gain and organize knowledge about matter, scientists sort substances into categories or groups in which substances have common **properties**. When you sort things in this way, you classify matter.

Read more about classification on pages 13 to 15 in the textbook. Then do the following questions in your notebook.

1. Write definitions for the following:

   a. mixture
   b. pure substance
   c. homogeneous mixture
   d. heterogeneous mixture
   e. phases

2. Use the particle model of matter to describe the characteristics of both homogeneous and heterogeneous mixtures.

3. What is the difference between a *suspension*, a *colloid*, and an *emulsion*? Give an example of each type of mixture.

4. Study the photograph on page 15 in the textbook, and predict the type of mixture that will result from mixing the indicated ingredients.

Check your answers with your teacher or home instructor.

In the next investigation you will see a set of symbols used throughout the textbook. The symbols alert you to take safety precautions when carrying out experiments. You must understand the meaning of each symbol to take necessary precautions and to follow safety hints included in the instructions of each activity or investigation.

For the complete list of caution symbols, and a detailed description of their meaning, turn to page 481 in the textbook and read "Skill Focus 1: Safety Symbols."

In the next investigation you will apply what you now know about classifying matter.

Investigation 1A Inspector's Corner

Refer to the "Inquiry Investigation" on page 16 of the textbook. Read the whole investigation to get a sense of what it involves. Think about the "Question."

You will be making a data table. Read about this in "Skill Focus 10: Organizing and Communicating Scientific Results" on page 513 of the textbook.

Use a pencil and ruler or generate your table on a computer. Print information neatly and ensure that the table has a specific title.

Follow the steps in "Procedure" on page 16. Place your data table in your notebook. Label the third column of the data table "Classification" rather than "Heterogeneous or Homogeneous." Classify at least six substances indicated in "Materials" or from the following list of sponge, jelly, paint, a freshly poured soft drink, spices, tea, hair conditioner, or an orange drink prepared from powder.

5. Fill in your classification data table according to "Procedure" steps 2 to 4.

6. Analyse your results. Describe how homogeneous materials and heterogeneous materials differ in appearance.

Check your answers with your teacher or home instructor.

To Dissolve or Not to Dissolve? That Is the Question.

Meridith was having friends over for a picnic on a warm, sunny afternoon. She prepared a fruit drink from a package of powder crystals. As she was mixing the crystal powder in a pitcher of water, she noticed that the powder crystals disappeared. Meanwhile, the water seemed to take on the expected colour of a beverage. She hadn't really thought about what happens to the powder in the water before; this time she did. Her wonder about the phenomenon almost distracted Meridith from the task of serving refreshments to her guests.

Read pages 17 to 19 of the textbook to find out more about substances **dissolving** in other substances. You will see that the particle model is very helpful in explaining what happens.

dissolving: the complete intermingling of solute and solvent particles due to strong attractions between the particles

7. Using the particle model of matter, describe how solid sugar mixes with water to form a solution.

8. When water evaporates, the water vapour dissolves into air. How does the particle model of matter account for this process?

9. **a.** Sugar dissolves in water. Are the attractions between sugar particles and water weaker or stronger than sugar/sugar and water/water attractions?

   b. Describe the attractive forces between oil and water particles.

10. Define the terms *solute*, *solvent*, and *soluble*.

Check your answers with your teacher or home instructor.

Solubility

What is the maximum amount of a certain solute that will dissolve in a certain amount of a certain solvent at a certain temperature? If you know the answer to this question, you know the solute's solubility.

To learn more about solubility, read "How Much Can Be Dissolved?" on pages 20 and 21 of the textbook.

saturated solution: a solution in which the maximum amount of solute has dissolved; all spaces between the solvent particles are full

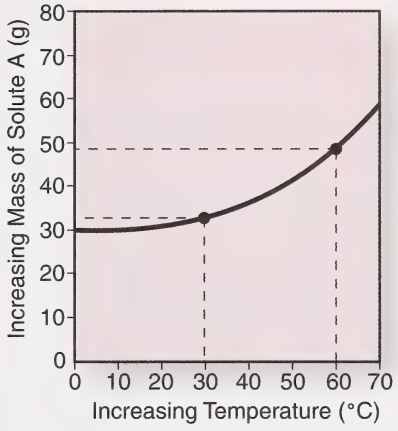
The saturation point is the point at which all of the spaces between the particles of the solvent have been filled. No more solute particles can dissolve into the solvent at a given temperature. If still more solid solute were added, the solute would simply fall to the bottom of the container and sit there. The solution is said to be a **saturated solution**.

unsaturated solution: a solution into which more solute could dissolve; there is still room for solute particles between the solvent particles

The solubility curve is a line that connects all the measured saturation points at different temperatures. Any solution below the solubility curve is an **unsaturated solution**. Any solution that falls on or above the solubility curve is saturated.

To use a solubility curve, first read the curve at two sample temperatures. For example, you may pick the temperatures 30°C and 60°C. The following graph shows that at the higher temperature, the corresponding mass of solute is also higher. Therefore, as the temperature increases, the solubility is higher. Also, more solute is needed to reach saturation. This solubility curve is typical for solid solutes in liquid solvents.

Solubility Curve and Saturation



11. Explain how temperature change generally affects the solubilities of solids.

12. How does the particle model explain saturated solutions?

supersaturated solution: a solution that contains more solute than would normally dissolve at that temperature

13. How can you create a **supersaturated solution**?

14. Do the "Pause and Reflect" exercise on page 21 of the textbook.

15. Do the "Math Connect" problem on page 21 in the textbook. **Note:** 1 g of water has a volume of 1 mL. Refer again to the definition of solubility.

Check your answers with your teacher or home instructor.

Going Further

Scientists who work with solutions frequently use computers to both determine and report information. Come up with your own scientific "solutions."

16. Try out "Computer Connect" on page 21 of the textbook.

Compare your responses with those in the Appendix on page 89.

manipulated variable: a variable that is changed on purpose to see what effect the change will have on the responding variable

responding variable: the variable that changes in response to a change of the manipulated variable

controlled variable: a variable that is not allowed to change

In a science investigation the investigator tries to find out what the effect of a change will be. For example, in studying plant growth, the investigator may change the amount of water for each potted plant. The investigator will watch to see if the height of the plants differs. The amount of water is the **manipulated variable**. The plant height is called the **responding variable**. For this investigation the amount of light and the temperature have to be the same for each potted plant. The amount of light and the temperature are called **controlled variables**.

In the next investigation the manipulated variable is the type of solute. The responding variable is solubility. A controlled variable is temperature.

Investigation 1B Solubility Solutions

Refer to the "Inquiry Investigation" on pages 22 and 23 of the textbook. Read the information at the top of page 22. Use steps 3 to 8 of "Procedure" as a guide.

Alter the procedure to avoid the need for a balance or test tubes.

Instead of test tubes you can use a clear glass for each solution.

You may pour 100 mL of water into each glass. Then mix 15-mL spoonfuls of solute to make a saturated solution.

Just use table salt, sugar, and baking soda. You may also use Epsom salts and alum if you have them. Mixtures of these substances can be safely disposed of by flushing them down the toilet.

Record the solubilities of each solute in the number of 15-mL spoonfuls per 100 mL of water. Using this measure will allow a fair comparison of solubilities.

17. Do questions 1 to 3 of "Analyze" and "Conclude and Apply."

18. **a.** Is the solubility of a substance the same at all temperatures? Explain.

b. Does solubility always increase with an increase in temperature? Provide examples.

19. Explain the difference between solubility and the rate of dissolving.

Check your answers with your teacher or home instructor.

Going Further

Are you ready for more solutions? Extend your knowledge as you do question 4 of "Extend Your Skills" on page 23 of the textbook.

You will investigate how rock potash is mined by creating an underground solution.

Solvents Other Than Water

Have you ever watched someone try to wash off nail polish with water? Maybe you tried this yourself. Using water just doesn't work. Not even soap and water succeeds.

Removing nail polish requires a solvent other than water—use nail polish remover and it's easy. Nail polish and nail polish remover mix to form a **non-aqueous solution**. So keep in mind that not every solution is an **aqueous solution**.

non-aqueous solution: a solution that has a substance other than water as the solvent

Some solutions contain water as the solute rather than as the solvent. Ethylene glycol, as antifreeze, is mixed with water as an engine coolant. Such a solution does not freeze and expand as water does by itself. Using antifreeze in winter protects your family's car engine from the freezing and the expansion of the coolant.

aqueous solution: a solution that has water as the solvent

For maximum protection a solution of 60 parts ethylene glycol and 40 parts water is used. In this case the antifreeze is the solvent because it is the more abundant substance, and the water dissolved in it is the solute.

Another example of a solution containing water as the solute is rubbing alcohol. It's sold as a solution made up of 70 parts isopropyl alcohol and 30 parts water. Because there is more isopropyl alcohol than water in the mixture, water is considered to be the solute and alcohol the solvent.

There's even more to tell about mixtures. Did you know that solutions are not all liquids? There are also solid solutions. You have probably seen dental fillings either in your own teeth or in those of a friend. These fillings are dental amalgams—an alloy of mercury mainly composed of silver. Another example of a solid solution is brass, which is a homogeneous mixture of copper and zinc. You have probably seen trumpets made of brass.

The properties of solvents determine how they can be used. Turn to page 24 of the textbook and read "Cleaning Up with Solvents."

20. Explain how soap or detergents help to remove greasy stains.

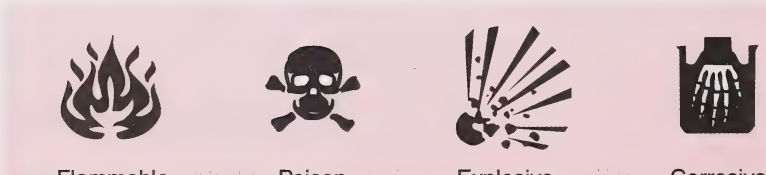
Check your answers with your teacher or home instructor.

Hazardous Substance Safety

Potentially dangerous products sold for home use often have Hazardous Household Products Symbols (HHPS) on them. Study the following HHPS symbols.

Frames

Icons



The HHPS symbols are a combination of the illustrated frames and icons. Frames show the degree of the hazard, while icons display the specific type of hazard.

For example, is the HHPS symbol warning you about corrosive materials.

Potentially dangerous products used in workplaces are identified by Workplace Hazardous Materials Information System (WHMIS) symbols. Some products with WHMIS symbols are also used around your home. To refresh your memory about WHMIS symbols, read page 25 of the textbook and "Skill Focus 1: Safety Symbols," on page 481. Notice that the WHMIS symbols on page 481 all have round frames.

Find Out Activity: Safety First

Refer to the "Find Out Activity" on page 25 of the textbook.

21. Do steps 2 to 4 of "Procedure" for four hazardous household containers. Record and interpret both WHMIS and HHPS symbols. **Note:** Only the WHMIS symbols are round. The HHPS symbols have straight-sided frames.

22. Answer questions 1 and 2 of "What Did You Find Out?"

Carefully read, think about, and discuss question 3 of "Extension" with your instructor—and other students if possible. Waste disposal and the resulting short-term and long-term effects on our environment need serious consideration. Knowing how to safely dispose of wastes, and doing so, is everyone's responsibility.

Check your answers with your teacher or home instructor.

23. To test your understanding of the concepts in this lesson, answer questions 1, 3, 5, and 8 in "Topic 2 Review" on page 26 of the textbook.

Check your answers with your teacher or home instructor.

Going Further

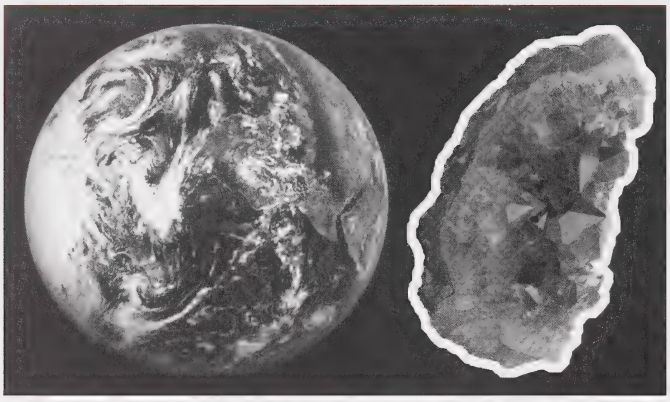
Check out the "Looking Ahead" reminder on page 26 of the textbook.

Looking Back

In this lesson you examined and explained what happens when a substance dissolves in a fluid. You also classified matter into pure substances and mixtures.

Turn to Assignment Booklet 1A. Complete questions 2 to 7 from Section 1.

Lesson 3: Separating Earth's Mixtures



Earth's atmosphere, crust, and oceans all provide substances to support and improve people's lives. However, these substances rarely exist in a pure state. Instead, they occur as components of mixtures. That is why finding processes and technologies to separate the planet's mixtures is so important. Separating crude oil into its components is the foundation of Alberta's petroleum industry. Separating mixtures into their parts is the topic of this lesson.

You need some knowledge of the properties of each component of a mixture to properly select a method to separate it. Some mixtures can be separated by physically picking out chunks of the substances in them—others require sophisticated processes and technologies to separate them.

Separating Components of Mixtures

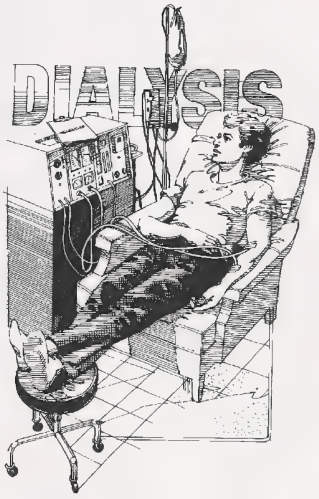
You may have gone to a party where you were asked to bring some labelled music CDs. With everyone bringing some CDs, there were plenty of music tracks to play.

What if the person handling and playing the CDs was not careful about separating them? She would end up with one pile of everyone's CDs.

At the end of the party the pile of CDs would have to be separated according to who owned them. That would take a while, but they would be easy to identify and return to the owners because of the labels on the CDs.

Imagine trying to separate the various types of particles in a mixture. They are not conveniently labelled and may not even be visible. What a task!

Separating mixtures can be of life-saving importance. Your kidneys filter both toxins and excess substances from your blood. If your kidneys fail, a dialysis machine will have to perform this essential function.



Turn to the textbook and read pages 28 to 31. You will find out about various ways of separating mixtures and where these methods are used.

1. What is the difference between distillation and evaporation?

2. What physical property of crude-oil components makes it possible to separate the components by using the fractional distillation process?

3. Answer the "Math Connect" question on page 33 of the textbook.

Check your answers with your teacher or home instructor.

Going Further

What do fertilizer, duct tape, and chewing gum have in common? Try the "Internet Connect" on page 31 of the textbook to find out.

Filters can be used to separate mixtures—but not all mixtures. In the next investigation you will try using a filter to separate mixtures.

Investigation Separating Mixtures

Question

What class or classes of mixtures can be separated by using filtration and evaporation?

Materials

- two clear containers
- a funnel
- one measuring cup
- a 15-mL measuring spoon (or one tablespoon)
- two large water glasses—each approximately 500 mL
- two flat plates
- a scientific filter-paper disc or a coffee filter
- sand
- salt
- a magnifying glass
- water

Procedure

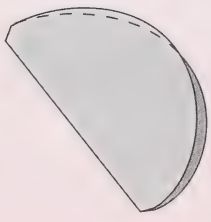
filtrate: the liquid that passes through a filter

residue: the material left behind following filtration or distillation

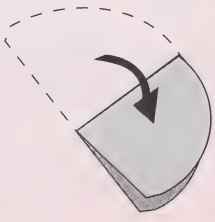
Step 1: Create a data table with a pencil and a ruler and use the following headings: Mixture; Appearance of **Filtrate**; Appearance of **Residue**. Be sure to plan ahead. Create a title.

Step 2: Mix approximately 50 mL—about three tablespoons—of sand with 250 mL of water in a clear container. Stir thoroughly.

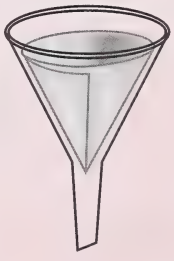
Step 3: Place the filter snugly inside the funnel. If you are using a scientific filter-paper disc, fold it as illustrated before placing it inside the funnel.



Fold the filter paper in half—crease lightly.



Fold the paper into quarters to form "pockets."



Open a "pocket" and slide the filter paper into the funnel.

Step 4: Carefully pour the sand and water mixture onto the filter paper. The mixture level in the funnel must be below the top edge of the filter paper.

Step 5: Collect the liquid filtrate in a tall water glass. Do not throw your filtrate away. You will need it for step 9.

Step 6: Record your observations in your data table.

Step 7: Mix approximately 50 mL—about three tablespoons—of salt with 250 mL of water. Stir thoroughly.

Step 8: Repeat steps 3 to 6 for the salt mixture.

Step 9: Pour a thin layer of each filtrate onto a different plate. You may also want to use two additional plates for tap water and distilled water. Put the plates in a warm place until all the water has evaporated. Record your observations. Using a magnifying glass may be helpful.

4. Did any substances other than the solvent—water—pass through the filters? How do you know?

5. Think of filters in your body, in a car, in your home, and in recreational facilities. List at least five of these filters.

Check your answers with your teacher or home instructor.

Going Further

Suppose that you were managing a community event and wanted to separate the neighbourhood kids by running ability. One way would be to have them line up on a track and start running a race. The kids would separate according to their ability to move or migrate down the track. The kids would spread out—the faster kids near the front and the slower ones straggling behind.

There is a technique for separating dissolved substances based on the way you separate people by having them run. This technique is called chromatography. It works by taking advantage of the different rates of migration of dissolved substances through a sheet of paper.

For example, chromatography can separate pigments in the ink of felt-tip markers.

Chromatography has many applications in science, medicine, and industry. To investigate a few applications, try the "Extend Your Knowledge" question on page 35 of the textbook.

Real-Life Separation Applications

The next investigation introduces you to real-world applications of the concepts you have been studying in this lesson.

Investigation 1E: A Sweet Process

Refer to the "Think and Link Investigation" on pages 36 and 37 of the textbook.

6. Read through the information in the flowchart on page 36. Answer the questions from "Analyze" on page 37.

Check your answers with your teacher or home instructor.

Going Further

Treating sewage costs money. Find out how much it costs.

7. Do "Math Connect" on page 87 of the textbook.

Treating sewage can be a highly technical process. Calgary is a world leader in waste processing and recycling. To learn more about some of the interesting technologies involved in sewage treatment, try "Exploring Further" on page 87 of your textbook.

8. To test your understanding of the concepts in this lesson, answer textbook questions 3, 5, and 8 from "Topic 3 Review" on page 38 of the textbook.

Check your answers with your teacher or home instructor.

Looking Back

In this lesson you explored ways of separating mixtures into their components. You also studied real-life applications in which mixtures are separated.

Section Review

To review the concepts covered in this section, turn to page 39 in the textbook. Answer questions 1(a), (c), (d), and (h), as well as questions 3, 4, and 6 of "Wrap-up: Topics 1 to 3."

Check your answers with your teacher or home instructor.

Conclusion

In this section you used the particle model of matter to explain the behaviour and properties of solids, liquids, and gases. Matter exists as pure substances or mixtures. Most matter exists as a mixture. Mixtures are either heterogeneous or homogeneous. Heterogeneous or mechanical mixtures have distinguishable parts and can often be separated by mechanical means such as settling or filtration. Homogeneous mixtures—solutions—have indistinguishable parts and may be separated by evaporation, distillation, and crystallization.

You demonstrated that there is a limit to the amount of solute that can be dissolved in a solvent, and you examined some separation techniques. You were also introduced to a variety of scientific and industrial applications.

An ice-cream sundae is a delicious treat. The next time you enjoy one, you will be consuming a complex mixture.

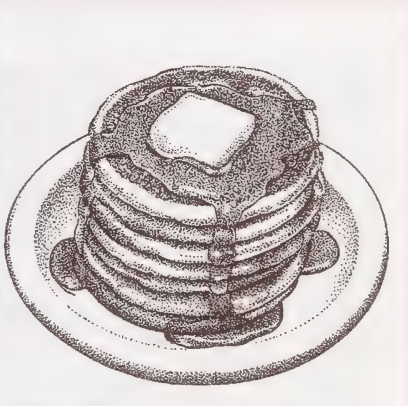
Turn to Assignment Booklet 1A. Complete questions 8 to 15 from Section 1.

Section 2

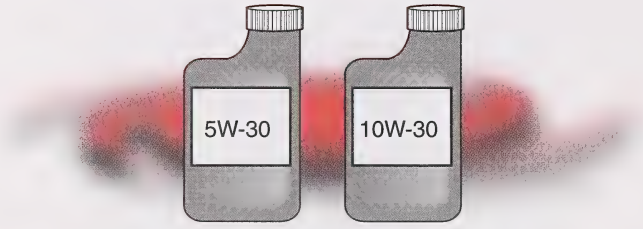
Properties of Fluids

What characteristics of fluids are responsible for their various behaviours? Why does liquid honey flow slowly like motor oil but sink when it's poured into water? Why does a metal boat float on water while a small block of metal sinks? What allows a hot-air balloon to stay in the sky?

In this section you will investigate the fluid properties that explain these phenomena. You will also develop your science investigation skills.



Lesson 1: Flow Rate and Viscosity



Ashley was helping her father change the oil in their van. After they had drained the old oil and replaced the filter, Mr. Jameson asked Ashley to bring him four litres of oil from the shelf. She went to the shelf but saw some cans labelled 5W-30 and some 10W-30. She hollered back to her dad and asked which she should bring.

"Bring the 5W-30," he said, "since it's still winter." This puzzled Ashley.

As Mr. Jameson poured the oil, he asked Ashley if she had heard the expression "as slow as molasses in January" used for someone or something moving at a snail's pace. The expression uses the idea that a normally thick fluid, such as molasses, is even thicker in the cold and pours extremely slowly.

The effect of temperature on oil is similar. In cold weather the oil is thicker and does not flow as easily. This effect can make starting a cold engine difficult.

He explained to his daughter that winter oil and summer oil are different. Winter oil is designed to be thinner than summer oil at room temperature—when the winter oil is cold, it doesn't end up being as thick. This property of winter oil does two things during a cold start. It allows the engine to turn over more easily. It also helps engine lubrication during a cold start.

viscosity: the resistance of a fluid to flow

Mr. Jameson added that the 5W-30 oil is thinner than the 10W-30 oil; that's why the 5W-30 is a better choice for winter oil. The numbers indicate the **viscosity** of the oil.

In Section 1 you found the defining characteristic of fluids to be that they flow. The topic of this lesson, viscosity, determines how fast a fluid will flow.

The **flow rate** of fluids is a good indicator of their viscosity. For more about flow rate and viscosity, read page 40 of the textbook.

flow rate: the speed at which a fluid flows

Investigative Skill Development

You will now take a little detour. This change is designed to give you some insight into the investigative skills by which scientific knowledge is increased. Scientists use these skills to learn more about nature. You will also need such skills to gain your own scientific knowledge.

Some aspects of investigative skills will become clearer as you move through the course. Think of this as a good starting point in skill development. Information in this detour should also be used for reference material.

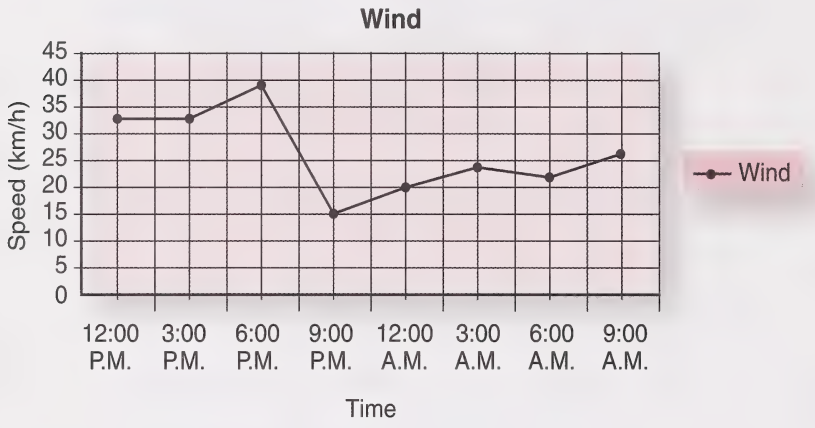
Have you ever been caught in a windstorm? Maybe you had difficulty seeing due to dust in the air. Staying on your feet may have been a challenge, while walking was an accomplishment.

Pincher Creek, located in southern Alberta, is known to be one of the windiest places in the province. Imagine walking to and from school in Pincher Creek. Some days you would not even want to think about riding a bicycle.

People who are interested in generating large-scale electricity from wind power have discovered that placing windmills near Pincher Creek is a good idea.

Graphs

Look at the following graph to see how wind speed changes in Pincher Creek over the period of time beginning at noon on a September day. The measurements of wind speed were made at three-hour intervals.



To find out if the relation shown by the graph is typical, you would have to repeat the investigation several times on different days in September.

Variables

Aside from showing something about the wind in Pincher Creek, the graph shows you how variables are involved in a scientific investigation. Variables are factors that affect an investigation. For the relation between wind speed and clock time shown on the graph, time is the manipulated variable and speed is the responding variable. When graphing, the manipulated variable is generally on the horizontal axis and the responding variable is normally on the vertical axis.

Suppose you were the scientist who collected the data. You would have freedom about when to measure the wind speed. You could choose to measure the wind speed every hour or assess it in some other way. The manipulated variable is the variable you can manage—that's why time is thought of as the manipulated variable. The word *manipulate* is another word for *change*, *manage*, or *handle*.

What about the responding variable? Once you select the times, you cannot then choose the value of the wind-speed measurements. There is a specific value of the wind speed that responds to or depends on the time at which you measure the wind speed. The responding variable takes on values that respond to the value of the manipulated variable. For example, the wind speed is higher at 6:00 P.M. than it is at 9:00 P.M. Therefore, wind speed is the responding variable.

Variables that you can too easily overlook are controlled variables. In the investigation of wind speed, the height at which the wind is measured must be fixed. That is, the height of the wind gauge must be kept constant. Another controlled variable is the location. You must make all your measurements at the same spot. Without controlled variables the investigation would not produce reliable results.

When designing and doing scientific investigations, it is important that you can identify the variables involved. When you can do that you gain a good sense of what the investigation is about.

To understand more about variables and scientific inquiry skills, read "Skill Focus 6: Scientific Inquiry" on pages 496 to 499 in the textbook.

After studying the skills focus, one student made the following notes to keep the kinds of variables straight.

> ***Manipulated variable (MV)***. To determine the manipulated variable ask the question: What am I going to be changing on purpose? Remember to plan the values of the manipulated variable. Write these values into the first column of the data table before doing the investigation. A change in the manipulated variable should cause a change in the responding variable.
>
> ***Responding variable (RV)***. This should change during the investigation as it responds to the change made in the MV. To determine the responding variable ask: What will I be measuring and recording? I must do the investigation to get this data. The responding variable is expected to change as it responds to the change made in the manipulated variable. Record the observed values of the responding variable in the second column of your data table as you do the investigation.
>
> ***Controlled variables (CVs)***. These are variables that must be kept the same throughout the investigation to be fair. To determine the controlled variables ask this question: Would the investigation be fair if I . . .? Think of factors that could change your results or make results difficult to interpret. These are the factors that must remain constant throughout the investigation.

1. Write definitions for the following terms in your notebook.

a. controlled variable (CV)
b. responding variable (RV)
c. quantitative data
d. qualitative data

2. To test your understanding of qualitative data and quantitative data, do questions (a) and (e) of "Instant Practice" on page 496 of the textbook. **Note:** There are two parts to each observation.

3. Carefully study the investigations illustrated on the top left-hand corner of page 498. In investigation (a), give the

   a. purpose of the investigation
   b. manipulated variable
   c. responding variable

Check your answers with your teacher or home instructor.

The Hypothesis

When you design a scientific investigation, you make a prediction. What do you think will happen based on what you already know? A prediction backed up by an explanation is known as a hypothesis. A complete format for a hypothesis is as follows.

If you (*increase, decrease, or change*) the (*manipulated variable*), then the (*responding variable*) will (*increase, decrease, remain the same, change, or any combination of these*) because (*you explain your prediction here*).

This may look quite complicated, and in some ways it is. You will see five parts if you look at it closely. Here is a hypothesis written out with one part per line.

If you _____

(increase, decrease, or change)

the _____,

(manipulated variable)

then the _____

(responding variable)

will _____

(increase, decrease, remain the same, change, or any combination of these)

because _____.

(you explain your prediction here)

When you write a hypothesis, think of the five parts. Enter them into the formula and you have a hypothesis.

Here is a sample hypothesis that relates to the investigation on page 498 of the textbook. It is represented by part (b), the top left illustration.

> If you *change*
> the *type of fertilizer a plant receives*,
> then the *height of the plant*
> will *change*
> because *the quantity and concentration of nutrients required for plant growth will vary. The plants that receive the fertilizer containing the most appropriate quantities of nutrients will be the tallest.*

It is important to read the explanation for your prediction again. Ensure that you have added **new** information that is **relevant** to the prediction. The explanation must not be just a rewording of the prediction.

Suppose the previous hypothesis was written this way.

> If you *change*
> the *type of fertilizer a plant receives*,
> then the *height of the plant*
> will *change*
> because *the type of fertilizer affects the height of the plant.*

In this form the explanation does not add any new information. Such a hypothesis is not well written.

Here is another hypothesis, but is is written in a slightly different form. If you look closely, you'll still see the five parts.

> As the amount of fertilizer increases, the height of a plant will increase until the concentration of fertilizer reaches a certain level. At this point, plant growth will begin to decrease. More fertilizer means more nutrients for plant growth. However, too much fertilizer can damage plant roots and prevent them from getting enough water.

You can convert your information into the other form.

> If you *increase*
> the *amount of fertilizer given to a plant*,
> then the *height of the plant*
> will *increase until the concentration of fertilizer reaches a certain level. At this point, plant growth will begin to decrease*
> because *more fertilizer means more nutrients for plant growth. However, too much fertilizer can damage the roots and stop them from getting enough water.*

The hypothesis needs to be clear and include the five parts.

Suppose the investigation results are the same as those predicted in the hypothesis. Then the investigation supports the explanation. That's why the explanation is so important.

Later, in the next investigation that you do, you will write a hypothesis.

The Procedure

In designing an investigation you need to develop a procedure. A procedure is often given as a series of steps to follow.

As you develop a procedure, carefully walk through the steps in your mind. Check that the steps are in a logical time-order. Make sure you answer these questions:

- Did you specifically tell how you were going to purposely change the MV and measure and record the RV?
- Does your procedure specify amounts, units, and time periods?
- Will the experiment be fair—did you deal with all the significant controlled variables?
- Have practical matters like labelling containers for later identification and measuring procedures been dealt with?
- Do you need a control to act as a standard for the experimental samples?
- Have you specifically stated the type of observations or measurements you will make?
- Have you planned a data table to record your observations?
- Have you provided instructions for analysing the data?

Later on in this lesson you will design a procedure.

Data Tables

Data tables are also important in science. In your investigations you use data tables for storing the manipulated variable, the responding variable, and maybe some additional observations and data analysis.

Carefully read "Skill Focus 10: Organizing and Communicating Scientific Results" on page 513 of the textbook.

There are a number of important standards for data tables. These standards help to make the data table easy to read. They are the following:

- Create a specific title for all tables, graphs, and diagrams.
- Be sure to use a pencil and ruler to draw the table, or use a computer.
- Print neatly in the data table.
- Measurement units are noted in the column headings—not in the data columns.
- The changes you will make to the MV are generally written into the first column before you do the investigation.
- The RV measurements or observations made during the investigation are generally placed in the second column. The RV column may be sub-divided into smaller columns to organize the data for different trials or tests.

Carefully study the following sample data table. Notice that force acting on a confined fluid is the manipulated variable. As well, volume is the responding variable.

The Effect of Force on Fluid Volume

Force Acting on a Confined Fluid (N)	Volume (mL)	
	(Trial 1) Air	(Trial 2) Water
0	60	60
100	30	60
200	20	60
300	15	60

This table meets the standards for data tables.

Applying Investigative Skills

In the next investigation you will be closely exploring viscosity, which is a fluid's resistance to flow. You should apply the scientific skills, concepts, and standards you have just studied.

In Part 1 of the investigation you will be manipulating the type of liquid, and its thickness, to determine how viscosity affects flow rate. In Part 2 you will measure the time an object takes to fall through a fluid to study the effect of fluid thickness and, therefore, viscosity.

Quickly scan Part 1 again on pages 41 and 42 of the textbook for a review. To investigate how thickness or viscosity affects the flow rate, it is important to think about all the possible variables that might affect your investigation. Examples may include the following:

- Which liquids provide a wide range of viscosities?
- What should the surface of the ramp be like?
- At what angle or angles should the ramp be placed?
- How much of each liquid should be released?
- How should the liquid be released?
- How will the flow rate be measured?
- Should the ramp be cleaned between trials?
- What should the temperature of the liquids be?

Investigation 1F Determining Flow Rate

Part 1

Refer to Part 1 of the "Inquiry Investigation" on pages 41 and 42 of the textbook.

You are first required to read through the entire investigation. Then use the information in the investigation, along with "Investigative Skill Development" information from earlier in this lesson, as you develop some elements of the Part 1 investigation.

The flow rate is an indicator of a fluid's viscosity or resistance to flow. In this investigation you will determine how the speed at which a liquid flows—its flow rate—is related to the thickness and viscosity of different liquids.

4. In your notebook, record the specific MV and RV you will be testing in this investigation. Also, list significant variables that must be controlled to ensure a fair investigation.

5. Rewrite the "Question" from the textbook—"How fast can different liquids flow?"—so that your manipulated and responding variables are clearly defined in your question. An easy question format that you could use is the following: How does the MV affect the RV? Simply insert the manipulated and responding variables into the appropriate spots in the formula.

Compare your responses with those in the Appendix on page 89.

6. Write a hypothesis for Part 1 of this investigation in this five-part format.

   If you _____ the _____, then the _____ will _____ because _____.

Materials

See the textbook information on page 41.

Procedure

Be sure to create your data table as outlined in the following "Observations" section before doing the entire "Procedure" from the textbook. Choose liquids with a wide range of thicknesses at room temperature. Avoid motor oil.

If you test liquids that are not listed in the textbook, check with your teacher or home instructor to ensure that the liquids are safe to both use and dispose of.

Get the help of your family, friends, or instructor, or write out different steps for the "Procedure," as necessary, to allow you to measure the flow rates by yourself.

Observations

7. Develop and draw a data table for storing your MV, RV, and any other required observations or data analysis. Be sure to use the data table construction standards provided in "Investigative Skill Development." These standards are found earlier in this lesson.

Review your written work and check your responses with your teacher or home instructor. Get the approval of your teacher or home instructor before physically carrying out your investigation.

Once you have this approval, do Part 1 of the investigation. Use the results to complete the data table of the previous question and the following "Analysis" and "Conclusion."

In your analysis you will have to determine the flow rate. The flow rate is found by dividing the distance travelled (in cm) by the time recorded. In this investigation the distance travelled is always 10 cm. You will divide 10 cm by the time recorded.

For example, suppose that you found a certain fluid took 5 s to flow 10 cm down the ramp. The flow rate of the fluid would be $\frac{10\,\text{cm}}{5\,\text{s}} = 2\ \text{cm/s}$.

Turn to Assignment Booklet 1B. Complete questions 1 to 5 from Section 2.

Think back to the hypothesis you made. Decide if your hypothesis was correct.

Would you like to parachute out of an airplane? Many people parachute just for fun. You might find the idea to be scary. You can fall pretty fast through the air—it's only the parachute that keeps you from falling too fast.

The next investigation is based on a falling object. You will make an object fall through various fluids to study a property of the liquids.

After using several scientific investigation skills in Part 1, you are ready to take the next step of developing your own procedure rather than just following steps already provided for you.

Part 2

Refer to Part 2 of the investigation on page 43 of the textbook.

In this investigation you will be determining the viscosity of different fluids based on the length of time an object takes to fall through the fluids.

You are required to read through the entire Part 2 investigation first; then use its information, the data provided in "Investigative Skill Development" and Part 1 of "Inquiry Investigation 1F," along with the following information to help you develop your own investigation.

Once you understand what you will be investigating, create a specific title for the investigation. Place this title in your notebook.

Question

8. Record the specific manipulated variable and the responding variable that you will be using in this investigation. List all the significant controlled variables.

9. Rewrite the "Question" in the textbook—"How fast can an object flow through different liquids?"—so that both your manipulated and responding variables are clearly defined in your question. Remember the question format—"How does the MV affect the RV?"

Hypothesis

10. Write a hypothesis for this investigation. Use the five-part format.

Materials

11. After thinking about your procedure, list the materials and equipment you require.

Procedure

12. Write a numbered, logically ordered list of the steps you will take during your investigation.

Do not drop a marble or a similar hard object in an empty graduated cylinder made of glass. The glass could break.

Observations

13. Develop and draw a data table for storing your MV, RV, and any other required observations or data analysis. Use the standards given in "Skill Focus 10" on pages 513 and 514 of the textbook.

Check your answers with your teacher or home instructor.

Analysis

Turn to Assignment Booklet 1B. Complete questions 6 to 9 from Section 2.

Think back to the hypothesis you made for Part 2. Decide if your hypothesis was correct.

Viscosity and Product Performance

Viscosity affects both the performance and the appeal of many products. For more information, read pages 45 and 46 in the textbook. Then answer the following question.

14. How was the viscosity of the furniture-stripping liquid changed to improve its product performance? Why?

Check your answer with your teacher or home instructor.

Going Further

If viscosity applications at work interest you, try the "Career Connect" on page 46 of the textbook.

How Does Viscosity Vary?

Have you ever been in a market or a store when it was extremely crowded? Moving past other people is slow and difficult. If you thought of yourself and others as particles, you could say that the particles do not move very quickly around each other.

Now think about particles in a fluid. If the particles do not move freely past each other, does this affect the fluid's viscosity?

For an answer, read pages 48 and 49 of the textbook. Be sure to check out "Off the Wall." The behaviour of helium seems impossible.

15. To move different liquids through tubes and pipes, the viscosity of the liquid has to be considered. The viscosity of the liquid determines what size of tubes should be used.

a. Why are slush straws and soft-drink straws different?

b. Suppose that you see two pipelines being put into the ground close to where you live. You notice that one uses a larger pipe than the other, and you know that one is an oil pipeline and the other is a water line. Assume that each carries the same amount of liquid. Which one is the water pipeline? Explain your answer by using the particle model and the viscosity of fluids.

16. To test your understanding of the concepts in this lesson, answer questions 2 to 4 of "Topic 4 Review" on page 49 of the textbook.

Check your answers with your teacher or home instructor.

Looking Back

In this lesson you investigated the viscosity of fluids and used the particle model to explain differences in viscosity. You also worked on the skills needed for science investigations.

Turn to Assignment Booklet 1B. Complete questions 10 to 13 from Section 2.

Lesson 2: Density

Which is more difficult—running on a packed, sandy beach or running in the water? You'd likely say, "In the water!" But how would you explain your answer? Could you now use the particle model in your explanation? What property of air and water would be responsible for this difference? Why can a solid move through a fluid? In this lesson you will explore the answers to these questions.

Mass Per Unit Volume

density: the amount of mass in a certain unit volume of a substance

Density is a property of substances responsible for making running through water so much more difficult than running in air. Density is the property you will investigate in this lesson.

1. How does the density of solids, liquids, and gases differ? Explain your answer by using the particle model of matter.

2. Why can you move through fluids but not through solids?

3. If a substance or object is less dense overall than the fluid it is placed in, it will float. If a substance or object is more dense overall than the fluid it is placed in, it will sink. Use these rules and some of the substances in Table 1.5 on page 52 of the textbook to decide in what order the following substances or objects would settle:

   - machine oil
   - mercury
   - an oak block
   - water

Do not ever handle mercury. Mercury is higly toxic!

Assume they were very gently put in a tall, narrow container and nothing was mixed. Record the order from the top of the container to the bottom.

It is important to note that 1 g/mL (a fluid measure) = 1 g/cm³ (a solid measure).

Check your answers with your teacher or home instructor.

The Relationship Between Mass and Volume

How are density, mass, weight, and gravity related? Or are they? Read page 53 of the textbook to find out. Then answer the following questions.

4. Write definitions for *mass*, *volume*, and *weight*.

5. What is the difference between mass and weight?

6. To practise calculating a mass-to-volume ratio, read "Math Connect" on page 55 in the textbook. Record the conversion.

7. **a.** Calculate the volume of a block of cheddar cheese measuring 10 cm wide, 30 cm long, and 4 cm high.

   b. If the block of cheese had a mass of 2 kg (2000 g), what would its mass-to-volume ratio be in g/cm³?

Check your answers with your teacher or home instructor.

Investigation 1H Determining Density

Refer to the "Inquiry Investigation" on pages 54 to 56 of the textbook. Read all of the investigation. You will need graph paper to complete this investigation.

Instead of physically doing the investigation, you will be using the data supplied in the following tables.

Substance Tested: Water				
A	B	C	D	E
Volume (mL)	Mass of Cylinder Only (g)	Mass of Cylinder and Substance (g)	Mass of Substance Only (g)	Ratio of Mass to Volume (g/mL)
50	105	155		
100	105	205		
150	105	255		
200	105	305		
250	105	355		

Substance Tested: Corn Oil				
A	B	C	D	E
Volume (mL)	Mass of Cylinder Only (g)	Mass of Cylinder and Substance (g)	Mass of Substance Only (g)	Ratio of Mass to Volume (g/mL)
50	105	151		
100	105	197		
150	105	243		
200	105	289		
250	105	335		

Substance Tested: Glycerol				
A	B	C	D	E
Volume (mL)	Mass of Cylinder Only (g)	Mass of Cylinder and Substance (g)	Mass of Substance Only (g)	Ratio of Mass to Volume (g/mL)
50	105	168		
100	105	231		
150	105	294		
200	105	357		
250	105	420		

Substance Tested: Molasses				
A	B	C	D	E
Volume (mL)	Mass of Cylinder Only (g)	Mass of Cylinder and Substance (g)	Mass of Substance Only (g)	Ratio of Mass to Volume (g/mL)
50	105	180		
100	105	255		
150	105	330		
200	105	405		
250	105	480		

Substance Tested: Sand				
A	B	C	D	E
Volume (mL)	Mass of Cylinder Only (g)	Mass of Cylinder and Substance (g)	Mass of Substance Only (g)	Ratio of Mass to Volume (g/mL)
50	105	195		
100	105	285		
150	105	375		
200	105	465		
250	105	550		

8. Copy the previous five tables into your notebook. For each of the tables, complete the missing data as if you were following steps like steps 2 to 7 of "Procedure" from Part 1.

9. Answer question 2 from "Analyze" on page 56 of the textbook. Think of all five data tables you made as you do question 2.

Check your answers with your teacher or home instructor.

Note that the data tables were made by adding 50 mL of substance to the graduated cylinder each time—not 100 mL. Column B has already been filled, according to step 2 of Part 1. And Column C has already been filled, according to step 4 of Part 1. What's left for you to do is make the calculations to fill in the missing data.

To review how to make a line graph, turn to "Drawing a Line Graph" on page 514 of the textbook.

10. Make a graph of your data using steps 1 to 5 of Part 2: "Procedure" as your guide. For your data, use the five data tables you just made—not class results. **Hint:** The data you need comes from columns A and D of the data tables.

Turn to Assignment Booklet 1B. Complete questions 14 to 16 from Section 2.

Going Further

Do you want a computer challenge? Try "Computer Connect" at the bottom of page 56 in the textbook.

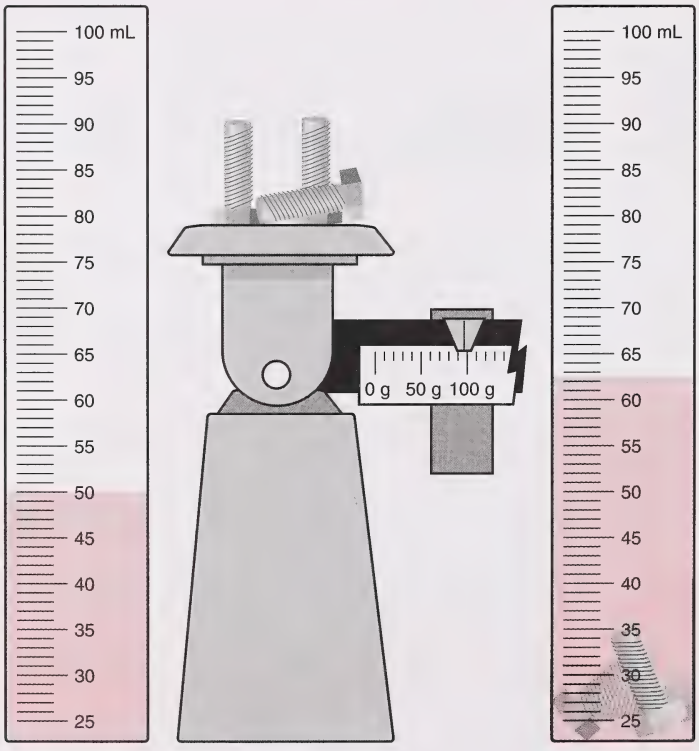
The Density Formula

You have calculated, graphed, and analysed several mass-to-volume ratios. In other words, you have calculated, graphed, and analysed several densities. In order to determine the density of an object, it is necessary to know its mass and volume. You can measure the mass directly with a triple-beam balance and determine the volume of a regularly shaped object by measuring its dimensions.

To find the volume of irregularly shaped objects, it's easy to use the displacement method shown in Figure 1.33 on page 53 of the textbook. Also check the boxed information on the bottom of page 492.

You will find the density formula and the units used to measure density as you read page 57 of the textbook.

Use the following diagram to answer questions 11 to 15.



11. What is the mass of the three bolts? **Hint:** The scale reads 97 g.

12. What is the volume of the three bolts?

13. What is the density of the metal?

14. Use Table 1.5 on page 52 of the textbook to identify what metal the bolts are probably made of.

15. To test your understanding of the lesson concepts, answer questions 1 and 3 from "Topic 5 Review" on page 58 of the textbook.

Check your answers with your teacher or home instructor.

Looking Back

In this lesson you compared substances on the basis of density, you formally defined what density is, and you used the particle model to explain differences in density.

Turn to Assignment Booklet 1B. Complete questions 17 to 20 from Section 2.

Lesson 3: Buoyancy

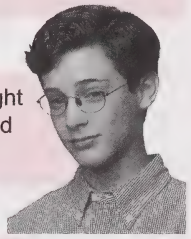
float: to remain suspended in a fluid either within the fluid or at its surface

buoyant force: the upward force exerted on an object or substance by a fluid

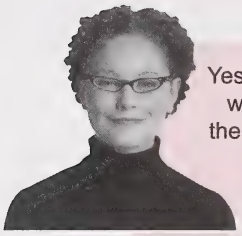
A dolphin can **float** in water. In other words, it can stay suspended in water without any effort. What keeps a dolphin suspended? It's the upward force exerted by water. This force is a **buoyant force**. The buoyant force opposes the downward force of gravity. If the buoyant force equals the downward force of gravity, the dolphin will stay suspended in the water.

buoyancy: the tendency of an object or substance to float in a fluid

Many things sink like a rock in water. Rocks and other things that don't float in water have low **buoyancy** in water. Suppose an object is let go under the surface of a fluid. Whether the submerged object floats or sinks in a fluid depends on two forces. These two forces are the buoyant force and the force of gravity on the object.



The force of gravity on an object is really the weight of the object, isn't it? So it is the buoyant force and the object's weight that affects what happens?



Yes, if the buoyant force is greater than the weight of the object, the object will rise to the surface. If the buoyant force equals the weight of the object, the object will stay suspended below the surface.

I can imagine what happens if the buoyant force is less than the weight of the object—I predict that the object will sink to the bottom.

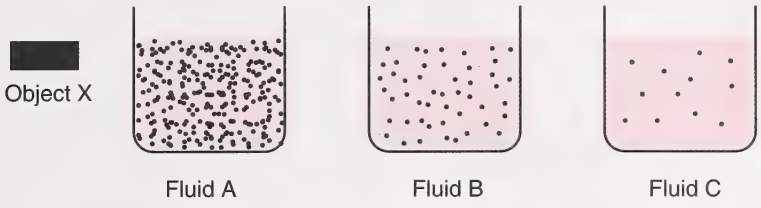
In this lesson you will find out if your predictions about submerged objects are correct. You will also see if they apply to fluids in other fluids.

You have already had many experiences with the buoyant force. You know that your friend is much easier to lift when in the water than when out of the water. This apparent difference in weight—the force of gravity pulling down on an object—is due to the upward push of the fluid's particles. Why does your rubber duck float in the bathtub?

Read all the textbook information on page 59 and on the top of page 61. Also read pages 62 and 63 to extend your knowledge about how and why things float.

You learned about density in Lesson 2. The average density of an object or substance relative to the density of the fluid it is placed in determines whether something will sink or float. While fluids push equally in all directions, buoyant force refers only to the upward push of particles in the fluid. The upward force opposes the force of gravity acting on the object or substance. In other words, the upward force opposes the weight of the object.

1. Consider the following diagrams. Assume all particles are similar in size and mass. Suppose Object X was submerged in each of the fluids.

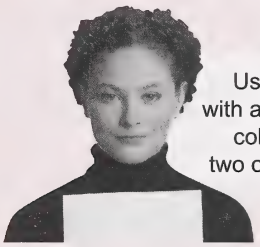


a. Which fluid would exert the greatest buoyant force on Object X? Why?
b. In which fluid would Object X appear to weigh the least? Why?

Compare your responses with those in the Appendix on page 90.

Investigation 11 Build a Density Tower

Refer to the "Inquiry Investigation" on page 60 of the textbook.



Use a wide-mouthed, transparent jar with a screw-on lid. Be sure to add food colouring to the water for clarity. Use two or three different-sized paper clips.

You have seen that liquids can exert a buoyant force on solids, but can liquids have this same effect on other liquids?

Carry out the steps of "Procedure."

2. Do questions 1 to 4 from "Analyze" and "Conclude and Apply."

Compare your responses with those in the Appendix on page 90.

You can change the weight of certain submerged objects without affecting their volume. This means that while such an object's weight changes, the buoyant force stays the same. By making the object's weight greater than the constant buoyant force, the object is made to sink. Alternately, by making the object's weight less than the constant buoyant force, the object is made to rise. A Cartesian diver is controlled in this way.

Find Out Activity Cartesian Diver

Refer to the activity on page 61 of the textbook.

Follow the steps in "What to Do."

3. Answer the questions from "What Did You Find Out?"

The Cartesian diver, named after René Descartes, the French scientist and mathematician, responds to pressure and works like a submarine.

Compare your responses with those in the Appendix on page 91.

The Average Density of an Object

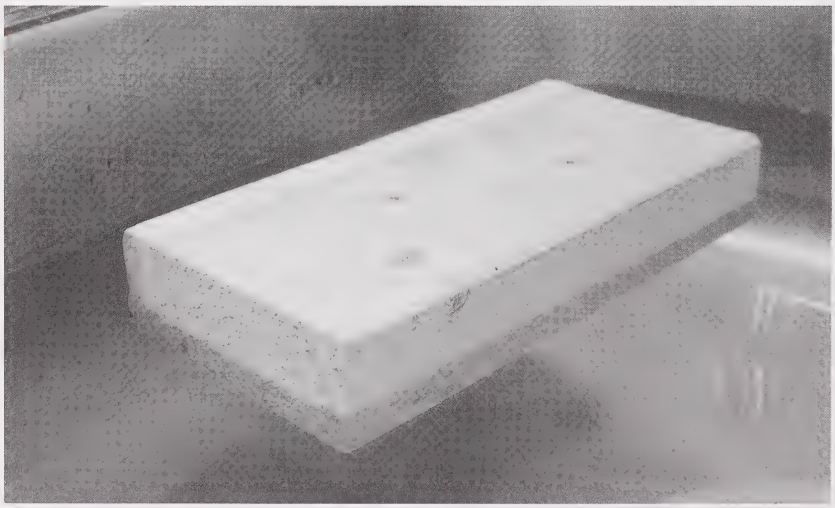
average density: the total mass of an object divided by its total volume

The Cartesian diver illustrates or models how fish and submarines both sink and rise in the water. The "diver" sinks when the volume of water in the medicine dropper increases as the air is compressed, and it rises when the air expands and pushes water out. You can explain the motion of the diver in terms of its **average density**.

Read pages 62 and 63 in the textbook to find out how average density is used by objects to either float or sink in a fluid.

4. Explain, in your own words, why ships made of steel can float.

Use this photo to complete the next question. The photo shows a piece of wood floating in water.



5. In Lesson 2 you determined the density of several substances, for example, glycerol. Describe what will happen to the block of wood when it's placed in a container of glycerol.

6. **a.** What organ in a fish is equivalent to a submarine's ballast tank?

   b. To start sinking, the fish and the submarine must both _____ their average density until the buoyant force pushing them up is _____ than their weight.

   c. To remain suspended at a particular depth in the water, the submarine's weight must equal the _____ of the water.

   d. When a hot-air balloon rises overhead you know that the average density of the balloon, the basket, the people, and the hot air in the balloon is _____ the density of the air.

Compare your responses with those in the Appendix on page 91.

Archimedes' principle: the principle that the buoyant force on an object is equal to the weight of the fluid displaced by the object

Archimedes' Principle

The principles of buoyancy were first stated by Archimedes, a Greek scientist. For a full account of **Archimedes' principle** and the phenomenon of **neutral buoyancy**, read pages 64 and 65 in the textbook.

neutral buoyancy: the condition of a submerged object in which the object's weight equals the buoyant force on the object

Put together facts you have discovered about objects submerged in a fluid:

- If the buoyant force on the object is greater than its weight, then the object will float.
- If the density of the object is less than the density of the fluid, then the object will float.

Do both of these statements fit the facts about the motion of an object in a fluid? That's what the next activity is about.

Recall that an object's average density can be calculated from the object's mass and volume.

The mass, in g or kg, of an object is easy to measure directly by using a triple-beam balance scale. An example is shown in Figure 1.31 on page 53 of the textbook.

If you don't have this type of scale, you can weigh an object using a spring scale. Small spring scales usually have a mass reading in grams.

For pictures of a spring scale in use, see pages 300 and 301 of your textbook.

The displacement technique is a method used to determine the volume of an object. In this technique the object is submerged in a liquid, for example, water. If the water is in a graduated cylinder the volume reading of the water will increase. The change in volume equals the volume of the submerged object.

The object may not fit in a graduated cylinder. Then you can put the object into a completely filled container of water. The water will then overflow the container. The volume of the overflow equals the volume of the submerged object.

In the next activity you will explore the buoyancy of objects. You will investigate how buoyancy relates to volume, to density, and to other characteristics of objects.

Find Out Activity Will It Float?

Materials

- a graduated cylinder or a measuring container made of glass

Do not use a scale for a tug-of-war or bounce things on it—the scale will break with rough use.

- water
- a spring scale
- several small light-weight plastic bags with a locking seal if possible
- a pitcher or a measuring cup with a spout
- a cake pan large enough to catch overflow from the pitcher

You will also need at least two waterproof objects small enough to fit in the pitcher, yet large enough to displace an amount of water that can be easily measured. As you follow the "Procedure" you may find that you need another object, since one of the objects should float in water and one should sink.

Procedure

Step 1: Into your notebook, copy the table "Objects Placed in Water—Predictions and Observations" from "Analysis," which is found later in this activity. Make one column for each object that you will be placing in the water. In your table, replace "Object 1" with the name of your first object and "Object 2" with the name of your second object, and so on if you are using more objects.

Step 2: Select your first object. Record your predictions in rows a. and b. for this object. **Note:** If a submerged object has an average density greater than the density of the fluid, it will sink. If the average density of the object is less than that of the fluid, it will rise.

Step 3: Hang the object from your spring scale. If necessary, place the object in a small plastic bag. Record the object's weight (N) and its mass (g) in table rows c. and d.

Step 4: Place the pitcher right against the cake pan so that any water flowing out of the pitcher will be caught in the cake pan. Fill the pitcher with water until it overflows. Empty the cake pan without bumping the pitcher. Then put the cake pan against the pitcher.

Step 5: Slowly and gently place the object into the overflow pitcher. The water displaced by the object will flow into the cake pan.

Do not touch the overflow pitcher!

Step 6: When the water has stopped flowing, without spilling, pour the displaced fluid into a small plastic bag and carefully hook the bag onto the spring scale. According to Archimedes' principle the weight of the displaced fluid equals the buoyant force acting on the object. Record the buoyant force under your object name in table row e.

Step 7: Carefully pour the water in the bag into your graduated cylinder.

The volume of the displaced fluid equals the volume of the totally submerged object.

If the object sank when you placed it in the overflow pitcher, record the volume of the displaced fluid—which equals the volume of the object—in table row f. If the object floated, replace the cake pan under the overflow pitcher's spout. Slowly push the object down until it has completely submerged. Hold it there until the water stops flowing. Add this additional displaced water to the graduated cylinder. Record the object's volume in table row f. This amount was obtained using the displacement technique.

Step 8: Complete table rows g., h., i., and j.

Step 9: Repeat steps 1 to 8 for at least one more object that preferably has a significantly higher or lower average density than the first one. If the first object floated, the second one should sink. If the first object sank, the other should float.

Analysis

7. Complete the table you made, like the following one, as you follow the steps in "Procedure." If you used just two objects, you only need to fill in two columns. **Note:** The abbreviation y/n means yes or no, while f/s means float or sink.

Objects Placed in Water—Predictions and Observations			
	Object 1	**Object 2**	**Object 3**
a. **Predict:** density greater than water (y/n)			
b. **Predict:** float at water surface or sink to bottom (f/s)			
c. **Weight** of object (N) from conversion on spring scale			
d. **Mass** of object (g)			
e. **Buoyant force** on object (N) = weight of displaced fluid (N) = (your measurement)			
f. **Volume** of object (cm^3) = volume of fluid displaced (mL) = (your measurement)			

g. Compare: weight of object (from c.) is greater than (>), equal to (=), or less than (<) the buoyant force (from f.)			
h. Actual observation: float at water surface or sink to bottom (f/s/neither)			
i. Density of object = (mass (g) divided by volume (cm^3) = (your calculation) (g/cm^3)			
j. Evaluate: Were your predictions correct? (y/n)			

8. Suppose you had to do the investigation all over again. List two ways that you would improve the way you did the investigation.

Check your answers with your teacher or home instructor.

Apply

9. Copy a table like the following in your notebook. Include a column for each of the objects you tested. Object 1, Object 2, and Object 3 refer to the objects you tested in water during steps 1 to 9. You may only need columns for two objects.

Floating or Sinking				
Fluid	Fluid Density (g/mL)	Float or Sink Behaviour (f/s)		
		Object 1	Object 2	Object 3
		Object 1 Average Density = ___ g/cm^3	Object 2 Average Density = ___ g/cm^3	Object 3 Average Density = ___ g/cm^3
helium	0.002	s		
ethyl alcohol				
machine oil				
water				
seawater				
glycerol				
mercury				

Refer to Table 1.5 on page 52 of the textbook. Fill in the column for fluid density on the table.

In the columns for your objects, indicate whether the object would float (f) or sink (s) in the fluid.

10. Refer to Figure 1.40 on page 64 of the textbook.

a. What is the volume of the student's hand?
b. What technique did you use to determine the volume?

11. Answer the question in "Pause and Reflect" on page 67 of the textbook.

Compare your responses with those in the Appendix on page 91.

You have just discovered that the buoyant force acting on an object equals the weight of the displaced fluid. Also, if the average density of an object is greater than the density of the fluid, the object will sink. If the object's density is lower than the density of the liquid, the object will float.

Using Buoyancy to Measure Density

So far you have used density measurements to make conclusions about buoyancy. You can also reason the other way. Knowing how an object behaves in a fluid allows you to make conclusions about density. A **hydrometer** is an instrument that takes advantage of this behaviour.

hydrometer: a device that uses buoyancy to measure the density of a liquid

Read "How Buoyancy and Density Are Related," on page 67 of the textbook.

In the next investigation you will study the buoyant force where the liquid density is varied. The buoyant force will be measured by the apparent loss of weight of an object rather than by the weight of the fluid displaced. As indicated by Archimedes' principle, either way of measuring the buoyant force should give the same result. After the measuring you will relate the change in buoyant force to the operation of a hydrometer.

Investigation 1J Measuring Buoyancy

Refer to the "Think and Link Investigation" on page 68 of the textbook. Scan the investigation to get the general idea.

Be aware that "weight in liquid" is the apparent weight of the submerged object. The actual weight of the object stays the same since the actual weight is due to the downward force of gravity on the object. While submerged the object seems to weigh less. The upward buoyant force of the submerged object opposes the downward force of gravity on the object. That's what makes the weigh scale read a lower value for the submerged object.

12. Complete the steps of "What to Do."

13. Do the questions from "Analyze."

Check your answers with your teacher or home instructor.

14. To test your understanding of the concepts in this lesson, answer questions 1, 2, 4, and 5 of "Topic 6 Review" on page 69 of the textbook.

Check your answers with your teacher or home instructor.

Going Further

If you are interested in a career that really buoys you up, or if you just think scuba-diving would be fun, complete the "Career Connect" on page 69 of the textbook.

Looking Back

In this lesson you investigated the buoyancy of substances in fluids. You found that the predictions from the beginning of the lesson were correct. You also studied the connection between the density of a fluid and the buoyancy force it exerts.

Section Review

To review the concepts covered in this section, turn to page 70 in the textbook and answer questions 2 to 8 in "Wrap-up: Topics 4 to 6."

Compare your responses with those in the Appendix on page 92.

Conclusion

In this section you discovered, through investigations, that fluids flow at different rates. The measure of how fast a fluid will flow is called viscosity. You found that viscosity is affected by temperature and that the particle model of matter helps to explain viscosity.

You also investigated two other related charateristics of fluids—density and buoyancy. Density changes with temperature and is measured with a hydrometer. Buoyant force is the upward force exerted by a fluid on an object or a substance. The buoyant force opposes the force of gravity. All fluids can exert this force on other gases, liquids, and solids.

The size of the buoyant force on an immersed object depends on the density of the fluid. Objects or substances float on the surface of a fluid if their density is less than that of the fluid and sink if their density is greater. If the densities are equal, the objects or substances will rest anywhere between the surface and the bottom of the fluid.

As shown in the photograph, you could be quietly drifting along with your friends in the baskets of hot-air balloons. The buoyant force of the fluid air is what allows you and your balloon to stay high above the ground with no visible means of support.

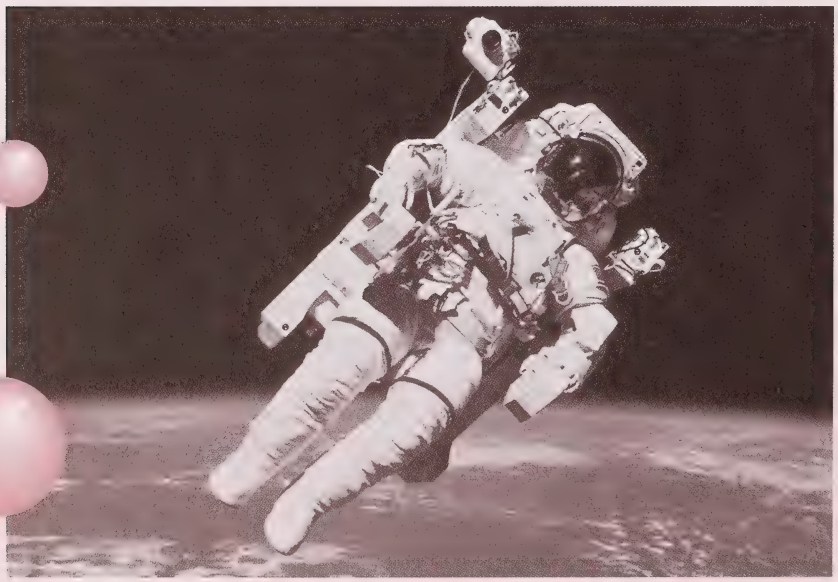
Turn to Assignment Booklet 1B. Complete questions 21 to 25 from Section 2.

Section 3

Working with Fluid Pressure

Have you ever wondered why astronauts need special suits when they float high above the atmosphere? Why do deep-sea divers also require custom suits when they swim far beneath the water's surface? Why do your ears pop when you are flying in an airplane or riding in a fast elevator? The reason is pressure. You are surrounded by pressure all your life. In fact, if the pressure of the atmosphere disappeared, you would not be able to live. As you discovered in Section 2, fluids can exert buoyant forces and they have different densities.

In this section you will discover that fluids exert pressure based on their density, depth, and motion. You will also investigate how fluid pressure is measured, what happens when forces are applied to fluids, and how people use fluids under pressure.



Lesson 1: Fluid Pressure

Have you ever walked through a deep layer of snow on snowshoes? What was your experience? How was it different from trying to walk on the snow in regular shoes? The graphic shows one person with snowshoes and the other without snowshoes. Wearing snowshoes sure is an advantage—as you probably would remember if you used them. You can travel much more easily over the snow rather than plodding through it.

Even if the people in the graphic weigh the same, the person without the snowshoes will sink deeper. The reason is that the plain shoes have a smaller surface area than the snowshoes. With the smaller surface area, the plain shoes apply greater **pressure** to the snow because of their smaller surface area. The greater pressure is more than the snow can support and so the snow gives way and the shoes drop into the snow.

pressure: the force per unit area

Surface area is one factor affecting pressure; another factor is the force being applied. Think back again to your experiences of walking in snow. Imagine two people—one heavier than the other—with snowshoes that have the same surface area. Of these two people, who will sink deeper into the snow?

The heavier person will sink deeper. Your thinking about being on snowshoes has brought out two factors affecting pressure. These factors are force and the area over which the force is applied.

In this lesson you will focus on the concept of pressure. You will determine the amount of pressure being applied, and you will investigate the effect of pressure on a gas.

Pressure due to an applied force can be calculated. To learn about the formula for pressure and the unit of pressure, read page 71 of the textbook.

1. Write down the pressure equation.

Since pressure is the amount of force (N) applied per unit area (m^2), the unit for pressure is N/m^2. Scientists have given this unit a name. They call N/m^2 a *pascal*.

pascal (Pa): a unit of pressure; newtons per square metre (N/m^2)

The **pascal (Pa)** is a tiny unit. It's equivalent to the pressure exerted by a 1 mm thick layer of water. Use the finger of one hand to touch the back of your other hand. When you can just feel the touch, you are applying about 1 Pa N/m^2 of pressure. Because the pascal is so tiny, pressure is usually measured in **kilopascals**.

kilopascal (kPa): 1000 pascals

2. A student named Noriko finds that the combined area of the soles of her feet is 0.051 m^2 and her weight is 534 N.

a. Calculate the pressure Noriko applies to the floor while she is standing.

b. How will this pressure change if Noriko stands on her toes? Check your prediction by using the pressure formula. Assume the area changes to 0.014 m^2.

Compare your responses with those in the Appendix on page 93.

Investigation Evaluating the Concept of Pressure

In a problem-solving investigation you use scientific knowledge to solve a practical problem. This leads to a challenge.

Note: For more information about scientific problem solving, read "Skill Focus 7" starting on page 502 of the textbook.

Challenge

To apply the concept of pressure to the design of real-life sitting devices.

Procedure

Step 1: Measure and record the approximate length and width, in metres (m), of the seating area of a kitchen chair. Calculate the seat's surface area that you contact when sitting. Do this procedure by using the following formula:

$$\text{Area } (A) = \text{length } (l) \times \text{width } (w)$$

Where l is the distance from back to front of the chair, the dimension w should be no more than your width on the chair.

Note: The width (w) is to be the width of the chair or the width of your bottom, whichever is smaller.

Step 2: Measure and record your weight in newtons (N). If your bathroom scale provides a mass reading in kilograms (kg), convert it to newtons.

One kilogram of mass has a gravitational force of approximately 10 N acting on it. In other words, 1 kg of any type of mass weighs 10 N.

$$\text{Therefore: weight (N)} = \text{mass (kg)} \times \frac{10\,\text{N}}{\text{kg}}$$

If necessary you could assume that your weight is 500 N.

Step 3: Calculate the force that is supported by a chair, or another seating device, when you sit. Assume the chair supports $\frac{9}{10}$ of your weight, since your feet are on the floor and absorb some of your weight.

$$\text{Force (N)} = \frac{9}{10} \times \text{weight (N)}$$

Step 4: Calculate the average pressure you apply to the seating area of your chair. The chair applies the same pressure on you when it supports your weight. Use the following pressure equation:

$P = \frac{F}{A}$,where P is pressure in N/m^2 or Pa, F is force in N, and A is area in m^2.

Place your answer in question 4 of "Application."

Step 5: Find a screwdriver with a flat tip. Measure and record the length and width of its tip in metres. Calculate the surface area of its tip (m^2). If necessary you can assume a surface area of 0.000 005 m^2 . Use the pressure formula to calculate the pressure you would experience on a screwdriver, and vice versa, if you could sit on it squarely. Place your answer in question 5 of "Application."

1 mm = 0.001 m

Do not actually try to support yourself on a screwdriver.

Application

3. What is the pressure when you sit on the chair? Show your calculations.

4. What would the pressure be if you sat on the screwdriver? Show your calculations.

5. Use the results of your investigation to explain why a designer "wastes" material when designing a chair with a large, rather than a tiny, seating area. Ignore the obvious balance problems.

6. A circus performer named Ammar is designing a bed of nails.

   a. Should Ammar choose a bed of nails made with many nails or only a few nails?

   b. Would it be more comfortable for Ammar to sit, stand, or lie on the bed? Explain.

Compare your responses with those in the Appendix on page 93.

The Compression of Gases

compressible: *capable of being squeezed into a smaller size or volume*

incompressible: *incapable of being squeezed into a smaller size or volume*

In Section 2: Lesson 3, you built a model of a diving device called a Cartesian diver. The medicine dropper sank when its average density increased as the volume of air in the dropper decreased. The air volume decreased due to the overall pressure increase inside the bottle. This demonstrates that air, a gas, is **compressible**. Water, on the other hand, is **incompressible**.

The particle model of matter can be used to explain the compressibility of gases and why liquids and solids are incompressible.

For more information, turn to page 73 in the textbook.

7. Using the particle model of matter, explain why it is possible to compress a gas.

8. What happens to a force when it is applied to a solid? Use the particle model of matter to explain.

Compare your responses with those in the Appendix on page 94.

Applying the Compression of Fluids

Read page 74 of the textbook to learn about some applications of the compressibility of gases.

9. How do the pockets of air in your running shoes decrease the force of your impact with the ground?

10. Air bags and tires both use the compressibility of gases. Compare and contrast the application of compressed gases in these two automotive technologies.

Compare your responses with those in the Appendix on page 94.

Find Out Activity Balloon Balance

Refer to the activity on page 75 of the textbook.

Gas particles have mass; gravity affects anything with mass. The weight of an object is the force of gravity acting on the object's mass. Prove to yourself that a gas has weight by doing this activity.

Follow the steps of "Procedure," according to the following change. Cut two equal pieces of adhesive tape. Place one piece on each of the inflated balloons. When you are ready to pierce one balloon, hold it gently and slowly stick the pin into the balloon through the tape. Slowly remove the pin. This should prevent the balloon from blowing up and allow you to control its weight. Once the balloon is mostly deflated, you can make the hole a little larger to release the rest of the compressed air. Be careful not to shift any of the strings.

11. Complete the questions of "What Did You Find Out?"

Compare your responses with those in the Appendix on page 95.

Atmospheric Pressure

Earth's atmosphere is often referred to as an ocean of air. This comparison makes it easy to visualize how atmospheric pressure affects us and everything around us. At sea level the average pressure of the atmosphere is 1×10^5 N/m^2 (Pa). This means the air would apply a force of 10 N to every cm^2 of your skin. Why don't you notice it? You will be able to answer this question after completing this lesson.

Keeping track of the atmospheric pressure is essential in meteorology, which is the study of atmospheric conditions. This is particularly true for weather forecasting. The instrument used to measure atmospheric pressure is a **barometer**.

barometer: a device used to measure atmospheric pressure

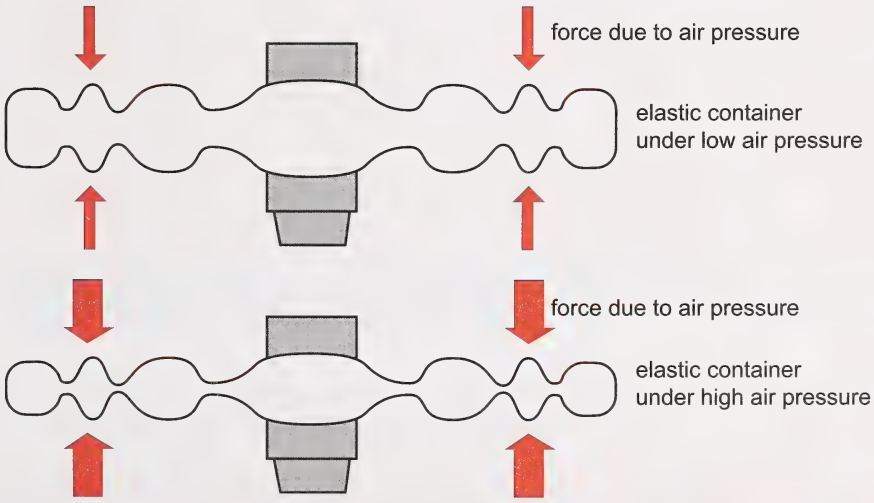
Measuring Atmospheric Pressure

Read pages 75 and 76 and "Did You Know?" on page 77 of the textbook to learn more about atmospheric pressure and how it is measured.

aneroid barometer: a type of barometer that contains no liquid

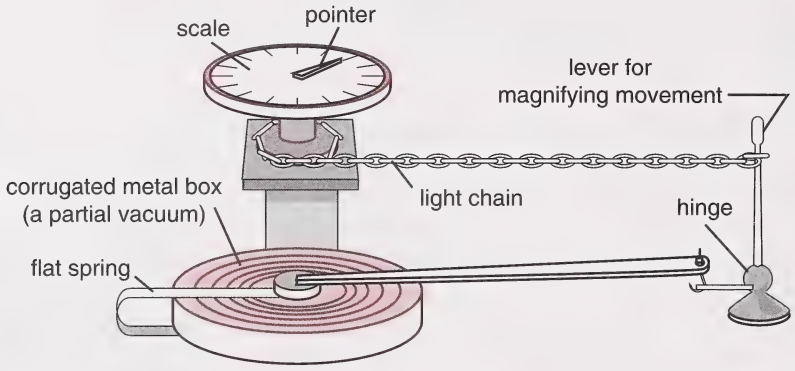
Although mercury barometers are still in use, a more common instrument is a version of the pictured **aneroid barometer**. The aneroid barometer eliminates the use of mercury and the risks it poses. In an aneroid barometer is a small metal container. The container has had some of the air removed from its insides before it is sealed. It then responds to changes in atmospheric pressure in a way similar to the juice container on page 76 of the textbook. The forces acting on the outside of the container must be balanced by the forces pushing out on the inside. As a result the container will expand if the atmospheric pressure decreases and collapse if the pressure increases.

The following diagram shows how the metal container of a barometer changes.



A pointer is connected by a series of levers to the container walls. The pointer moves over a scale to show air pressure.

The following diagram shows the internal parts of a commercial aneroid barometer.



12. Explain what will happen to a balloon inflated at sea level and then taken

a. to the top of a high mountain
b. 25 m under water

13. When you're driving down a long, steep part of a mountain road, your ear often experiences a "pop." What's responsible for this phenomenon?

Compare your responses with those in the Appendix on page 95.

Going Further

Do you feel like exerting a little extra pressure on something?

14. If so, try "Pause and Reflect" on page 76 of the textbook.

Compare your responses with those in the Appendix on page 95.

Find Out Activity Amazing Air Pressure

Prove to yourself that air exerts a surprisingly strong force. Impress your parents or a friend with the following demonstration.

Materials

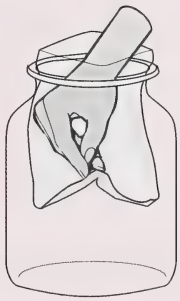
- one wide-mouthed jar, such as a 2-L jar of peanut butter
- one sandwich bag
- masking tape or duct tape

Procedure

Step 1: Place the sandwich bag over the mouth of the jar, and carefully push the bag inside the jar. Leave the edge of the bag hanging over the rim.

Step 2: Securely tape the edge of the bag to the jar's rim to make an airtight seal.

Step 3: Try to pull the bag out of the jar without tearing the bag.



Analyze

15. Explain your observations in terms of the volume and pressure both inside and outside the jar.

16. How would your observations differ if you moved your apparatus to the top of Mount Robson, with an elevation of 3954 metres?

Check your answers with your teacher or home instructor.

17. To test your understanding of the concepts in this lesson, answer questions 2 and 4 of "Topic 7 Review" on page 77 of the textbook.

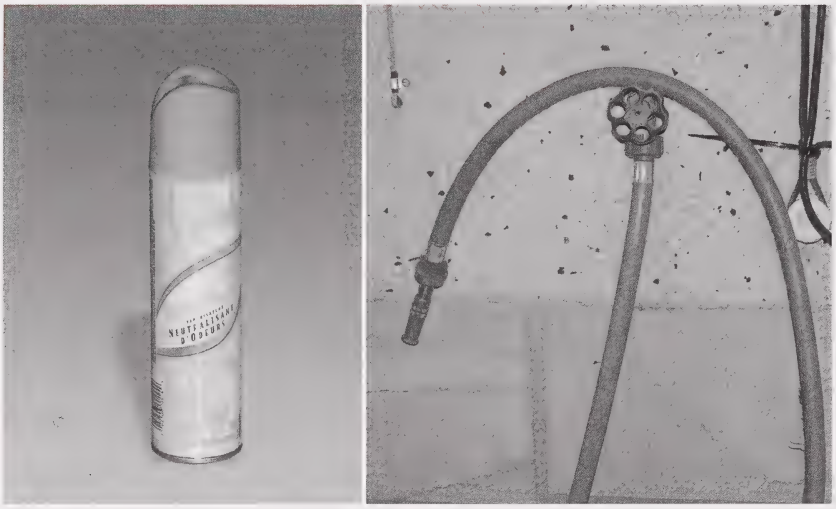
Compare your responses with those in the Appendix on page 95.

Looking Back

In this lesson you studied pressure and how it relates to the applied force and the area over which the force is applied. Also, you investigated the compression of a gas due to applied pressure. You then studied how the compressibility of a gas can be used for cushioning technological devices.

Turn to Assignment Booklet 1C. Complete questions 1 to 3 from Section 3.

Lesson 2: Fluid Systems



In this lesson you will investigate technologies that rely on the properties of fluids under pressure. Familiar technologies include car hoists, aerosol products, and garden hoses.

Read page 78 in the textbook and "Did You Know?" on page 79 to find out how two technologies function.

1. What is the acronym for chlorofluorocarbon?

2. How is a foam produced by an aerosol can?

3. Copy and complete the following statements.

   a. Particles always flow from areas of _____.

   b. Gases under pressure are _____ because the particles have _____.

   c. The force of gases under pressure can be used in many ways to _____.

4. Explain how a carbon dioxide (CO_2) fire extinguisher works.

Compare your responses with those in the Appendix on page 95.

Find Out Activity **Balloon Arm**

Refer to the activity on page 79 in the textbook.

5. Carry out the steps of "Procedure." Record your observations for steps 3 and 4. Answer both questions of "What Did You Find Out?"

Check your answers with your teacher or home instructor.

Hydraulic Systems

Liquids, like solids, are incompressible. In an enclosed system liquids transmit pressure equally in all directions. These two principles of **hydraulics** are the foundation of **hydraulic systems**.

hydraulics: the study of pressure in liquids

hydraulic systems: devices that transmit an applied force through a liquid to move something else by pressure

To reach a better understanding of hydraulic systems, carry out the next activity.

Find Out Activity Simple Hydraulics

Refer to the activity on page 80 of the textbook. As you read each step of "Procedure," refer to the same step number in the textbook diagram.

6. Answer both questions from "What Did You Find Out?"

Note: You need two syringes of different sizes.

7. Push on the large plunger to move the small plunger. Then push on the small plunger to move the large one. **Hint:** The larger plunger is in the syringe with the larger capacity. See the maximum mL readings on the scales.

a. Was the amount of force required to cause movement equal? Record your observations.

b. Did the pistons travel equal distances? Record your observations.

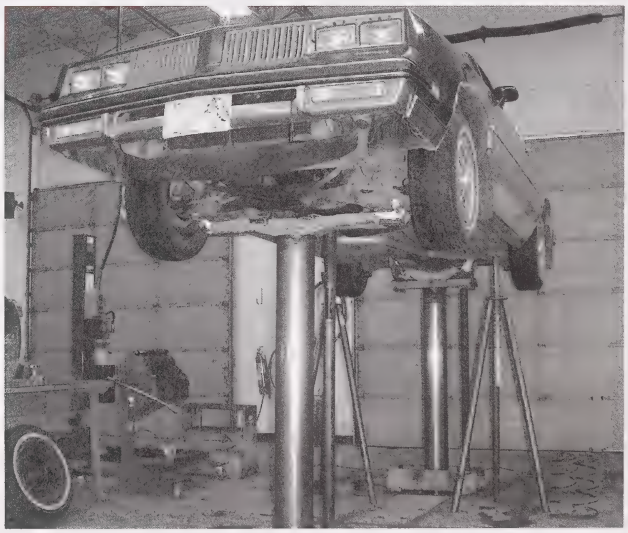
c. Based on your observations, predict what would happen to the applied force and distance travelled if you replaced your larger syringe with one that was even larger.

d. Can you suggest a "real-life" application for your observations?

Compare your responses with those in the Appendix on page 96.

A Hydraulic Application

A car lift in an automotive repair shop applies the hydraulic principles modelled in the preceding activity. A system of connected cylinders is used as a force multiplier. A relatively small force applied to one cylinder transmits pressure to a reacting cylinder. The reacting cylinder exerts a larger force that lifts the automobile. In the photo the car was lifted by two reacting cylinders.



8. A critical point to remember is that the pressure in a hydraulic system is the same throughout the system.

   a. Calculate the pressure in a system when you apply a force of 100 N on a plunger that has an area of 1 m^2.

   b. If this pressure is applied by the system to a 2 m^2 plunger, how large a load could you lift with your 100 N force?

   Hint: You can rearrange the pressure formula to $F = P \times A$.

   c. If the small plunger travelled 0.80 m, how far would the large plunger travel?

Compare your responses with those in the Appendix on page 96.

In explaining hydraulic systems, you relied on the notion that liquids are incompressible. To test this idea, and to compare the compressibility of liquids and gases, carry out the next investigation.

Investigation 1L Compression of Liquids and Gases

Refer to "Design Your Own Investigation" on page 81 of the textbook.

Maybe you do not have a syringe with a tip cap. If not, substitute a cork or an eraser with a hole part way through it.

If you design your own "Procedure" you must get approval from your teacher or home instructor before carrying out your steps. Make sure you indicate how your "Procedure" differs from the suggested textbook one. **Note:** In "Procedure step 1 c.," the column headings under "% Compression" should only be "Air" and "Water." Apply force only until you get a stable reading.

Look at step 4 of "Procedure." For that step, calculate the percent compression this way: $\frac{(A-B)}{A} \times 100\%$.

Turn to Assignment Booklet 1C. Complete questions 4 and 5 from Section 3.

Transporting Fluids

compressors: mechanical devices used to compress gases

Transporting fluids over long distances is another application of the principles of hydraulics. For information on the transport of fluids, another type of fluid system, and also **compressors**, read page 82 in the textbook.

9. a. How is pressure maintained in pipelines that are used to transport fluids?

b. How long does it take to transport a sample of natural gas from Alberta to Ontario?

pneumatic system: a system in which a gas, such as air, transmits a force exerted on the gas in an enclosed space

10. What device is used to pressurize a **pneumatic system**?

11. Name three applications of pneumatic systems.

For the next two questions you will need the large syringe you used earlier.

12. Pull the plunger of the syringe as far out as it will go. Use an elastic band to firmly attach a small, previously blown-up empty balloon over the small end. Lay your textbook on the balloon. Push in the piston.

a. Did the book rise?
b. Classify the system that you built.

13. Repeat the procedure from question 12, but fill the syringe with water instead of air.

a. Did the book rise?
b. Classify the system that you built.
c. Which system raised the book higher? Why?

14. To test your understanding of the concepts in this lesson, answer questions 1 and 3 from "Topic 8 Review" on page 84 of the textbook.

Compare your responses with those in the Appendix on page 96.

Looking Back

In this lesson you investigated how a force can be transmitted by fluid systems.

Section Review

To review the concepts from this section, turn to page 85 in the textbook and answer questions 1, 3, and 8 from "Wrap-up: Topics 7 to 8."

Compare your responses with those in the Appendix on page 97.

Conclusion

You should now know why astronauts wear special spacesuits when they hover high above the atmosphere. You have been surrounded by atmospheric air pressure all your life—that pressure has to be maintained or you wouldn't be able to survive. A spacesuit surrounds an astronaut with air under pressure so that the astronaut's life is sustained.

Through investigations you discovered that fluids—liquids and gases—exert pressure and that liquids are incompressible while gases are compressible. You also explored how fluids and their properties can be applied to everyday situations. Fluid systems, such as water and natural gas distribution systems, are an essential part of life. Fluid systems can be used to both lift weights and to apply force.

Going Further

"A-Mazing Hydraulics," the final project for Unit 1, gives you the opportunity to test and apply the concepts and techniques presented in this unit. Read about the project on pages 88 and 89 of the textbook. Follow these suggestions:

- Use the ideas as a guide for your own project.
- You can work alone or with others.
- Use appropriate materials from around your home or garage.
- Always check first with your teacher or home instructor.
- Be very aware of safety; ensure that you have proper adult supervision.
- Test your project on family and friends.
- Improve and revise your project as necessary.

Turn to Assignment Booklet 1C. Complete questions 6 to 9 from Section 3.

Module Summary

You studied the particle model of matter. In this model, all matter consists of extremely small particles that attract one another. The strength of this attractive force depends on the kind of particle—it also determines the behaviour and properties of a substance. There are three states of matter: solid, liquid, and gas. Matter can exist as a pure substance—composed of one kind of particle—or as a mixture of two or more substances. Mixtures are either heterogeneous or homogeneous.

You found that properties of fluids—such as buoyancy, density, and viscosity—determine their technological applications.

A force applied to an enclosed fluid results in fluid pressure. This pressure is exerted equally in all directions within the fluid. Hydraulic and pneumatic technologies, such as in automobile hoists, apply this principle to increase the applied force.

Fluids play an important role in human-made devices. For example, look at the irrigation sprayers in the photo. The water is a fluid under pressure. The pressure forces the water along pipes through a nozzle. At the nozzle the water escapes as a fast-moving spray that settles onto the crop. Without such irrigation sprayers, many regions would look more like deserts than rich farmland.

Module Review

To review the concepts covered in this module, turn to "Unit 1 Review" on page 90 in the textbook. Review the concepts listed under "Unit at a Glance." To help test your understanding, answer questions 1 to 5, 10, 12, 15, 16, 21, 27, 29, 34, and 37 on pages 90 to 93.

Compare your responses with those in the Appendix on page 98.

Turn to Assignment Booklet 1C. Complete the Final Module Assignment.

SCIENCE 8

APPENDIX

Glossary

Suggested Answers

Image Credits

Glossary

agitation: stirring or shaking with rapid action

aneroid barometer: a type of barometer that contains no liquid

aqueous solutions: a solution that has water as the solvent

Archimedes' principle: the principle that the buoyant force on an object is equal to the weight of the fluid displaced by the object

average density: the total mass of an object divided by its total volume

barometer: a device used to measure atmospheric pressure

buoyancy: the tendency of an object or substance to float in a fluid

buoyant force: the upward force exerted on an object or substance by a fluid

colloid: a heterogeneous mixture in which small, solid particles do not settle but are larger than dissolved particles

compressible: capable of being squeezed into a smaller size or volume

compressors: mechanical devices used to compress gases

concentration: the mass of solute dissolved in a certain amount of solvent (g/100 mL or g/mL)

conclusion: an inference or deduction drawn from observations, measurements, or facts

control: a sample that is not experimented on

The control acts as a standard against which all the experimental samples will be compared.

controlled variable: a variable that is not allowed to change

density: the amount of mass in a certain unit volume of a substance

dissolving: the complete intermingling of solute and solvent particles due to strong attractions between the particles

emulsion: a mixture in which droplets of fat are prevented from joining together by an emulsifying agent

fair test: an investigation in which variables are strictly controlled to ensure that the results are both reliable and accurate

filtrate: the liquid that passes through a filter paper or through a filtration device

float: to remain suspended in a fluid either within the fluid or at its surface

flow rate: the speed at which a fluid flows

fluid: a substance that can flow

Liquids and gases are fluids.

fluidity: the ability to flow

force: a push or pull

gas: a state of matter having neither a definite shape nor a definite volume; an airlike form

gravity: the attractive force between masses

Gravity causes things to fall down to the ground.

heterogeneous mixture: a non-uniform mixture consisting of more than one phase

This mixture is also referred to as a mechanical mixture.

homogeneous mixture: a uniform mixture of two or more substances that looks like one substance

This mixture is also referred to as a solution.

hydraulic systems: a device that transmits an applied force through a liquid to move something else by pressure

hydraulics: the study of pressure in liquids

hydrometer: a device that uses buoyancy to measure the density of a liquid

hypothesis: in an experiment or investigation, a testable prediction of what is expected to happen and an explanation of the reasoning behind the prediction

incompressible: incapable of being squeezed into a smaller size or volume

insoluble: not able to dissolve in a particular solvent

kilopascal (kPa): 1000 pascals

liquid: a state of matter having a definite volume but not a definite shape

manipulated variable: a variable that is changed on purpose to see what effect the change will have on the responding variable

mass: the amount of matter in an object

matter: anything which has mass and occupies space

mechanical mixture: a non-uniform mixture with two or more visible parts or phases; similar particles remain clumped

This mixture is also referred to as a heterogeneous mixture.

mixture: matter that consists of two or more substances; individual properties may combine

model: a visual, mathematical, or verbal representation of a process or structure

neutral buoyancy: the condition of a submerged object in which the object's weight equals the buoyant force on the object

non-aqueous solution: a solution that has a substance other than water as the solvent

pascal (Pa): a unit of pressure; newtons per square metre (N/m^2)

phases: distinctly different parts of a mechanical mixture

pneumatic system: a system in which a gas, such as air, transmits a force exerted on the gas in an enclosed space

pneumatics: the study of pressure in gases

prediction: a statement that proposes or forecasts the outcome of an investigation

pressure: the force per unit area

property: a characteristic that can be used to identify or describe a substance

pure substance: matter that consists of only one kind of particle

qualitative data: non-numerical information that relies on a comparison between objects; gathered without measurement

For example, It is warmer today than it was yesterday. The "l" in *qualitative* reminds you that you use "language" for the data instead of numbers.

quantitative data: numerical information that is absolute—it doesn't require a comparison; usually obtained through measurement or calculation

For example, It is 22° C today.

rate of dissolving: how fast a solute dissolves in a solvent

residue: the material left behind following filtration or distillation

responding variable: the variable that changes in response to a change in the manipulated variable

saturated solution: a solution in which the maximum amount of solute has dissolved; all spaces between the solvent particles are full

solid: a state of matter having a definite shape and a definite volume, such as a brick

solubility: the mass of a solute that can dissolve in a given amount of solvent to form a saturated solution at a given temperature

soluble: able to be dissolved in a particular solvent

solute: a substance that dissolves in a solvent; usually the smaller quantity in the solution

solution: a uniform mixture of two or more substances that looks like one substance

A solution is also referred to as a homogeneous mixture.

solvent: a substance that dissolves a solute to form a solution; usually the larger quantity in the solution

sublimate: to change from a solid to a gas or from a gas to a solid without becoming a liquid

supersaturated solution: a solution that contains more solute than would normally dissolve at that temperature

suspension: a heterogeneous mixture in which larger particles settle slowly after mixing

theory: a hypothesis that has been supported by a large volume of rigorously collected evidence, usually over a long period of time, and has been accepted by many scientists

unsaturated solution: a solution into which more solute could dissolve; there is still room for solute particles between the solvent particles

variable: any factor that could change during the course of an experiment

viscosity: the resistance of a fluid to flow

viscous: having a high viscosity; thick

volume: the measurement of the amount of space occupied by a substance

weight: the force of gravity exerted on a mass

Suggested Answers

Section 1: Lesson 2

16. Textbook question, "Computer Connect," page 21:

There are various ways to use a spreadsheet. The following shows spreadsheet formulas that will work.

	A	B	C	D	E	F
1	Mass of Solutes for Saturated Solutions					
2	Substance	g/100 mL	g/10 mL	g/50 mL	g/500 mL	g/1000 mL
3	alum	11.4	=B3/10	=B3/2	=B3*5	=B3*10
4	copper (II) sulfate	31.6	=B4/10	=B4/2	=B4*5	=B4*10
5	Epsom salts	70.0	=B5/10	=B5/2	=B5*5	=B5*10
6	salt	35.7	=B6/10	=B6/2	=B6*5	=B6*10
7	sugar	179.2	=B7/10	=B7/2	=B7*5	=B7*10

The solubility results are the following.

Saturated Solutions					
Substance	**g/100 mL**	**g/10 mL**	**g/50 mL**	**g/500 mL**	**g/1000 mL**
alum	**11.4**	**1.14**	**5.7**	**57**	**114**
copper (II) sulfate	**31.6**	**3.16**	**15.8**	**158**	**316**
Epsom salts	**70.0**	**7.00**	**35.0**	**350**	**700**
salt	**35.7**	**3.57**	**17.85**	**179**	**357**
sugar	**179.2**	**17.92**	**89.6**	**896**	**1792**

Section 2: Lesson 1

4. The MV is the thickness of the liquid. It could also be the type of liquid, but this is a less specific possibility—it does not refer to the characteristic you are actually manipulating.

The RV is the flow rate or the time required to flow 10 cm. The time the measurement you are actually making; the flow rate will then be calculated from it.

The following items are the controlled variables (CVs):

- the temperature of the liquids
- the amount of liquid
- the ramp's angle
- the ramp's surface
- the ramp's cleanliness
- the distance liquid travels
- the method for releasing liquid
- the timing technique

5. Answers will vary. Here are two examples:

   - How does the thickness of a liquid affect its flow rate?
   - How does the type of liquid affect the time required for it to flow 10 cm?

Section 2: Lesson 3

1. **a.** Fluid A would exert the greatest buoyant force on Object X. This fluid has the greatest number of particles. In this fluid there would be the greatest number of particles hitting the surface of the submerged object. Therefore, the buoyant force would be greatest in Fluid A.

   b. Object X would appear to weigh the least in Fluid A. The buoyant force is greatest in this fluid. The buoyant force opposes the force of gravity on Object X. The greater the buoyant force, the smaller the weight appears to be.

2. **Textbook questions 1 to 4 from "Analyze" and "Conclude and Apply," page 60:**

   1. Answers will vary. Pure water at 20°C has a density of 1 g/mL. The densities of all other substances will vary from sample to sample. Wood, for example, varies from 0.1 g/cm^3 in a balsa tree to 0.9 g/cm^3 for an apple tree. The density of cork is generally around 0.2 g/cm^3, and oil's density is about 0.9 g/mL.

      The following is a sample data table.

Density Ranking of Objects	
cork	**1 (least dense)**
paper clip	**5 (most dense)**
toothpick	**2**
vegetable oil	**3**
water	**4**

   2. Substances denser than water sink in water. An example is paper clips. Substances less dense than water, such as vegetable oil and cork, will float in water.

   3. A solid can be less dense than a liquid if there are spaces between the particles. Cork is less dense than water. The particles are held tightly together but with spaces between them. This gives cork more mass for each cubic centimetre of volume.

   4. The density of a solid object has no relationship to its volume. The density of an object depends on the material it is made of. **Note:** As an example, take two bolts of the same material but of different sizes. Suppose the larger one has twice the volume of the smaller one. Then the larger bolt will also have twice the mass if the mass of the smaller one is they are made of the same material. You can see that the mass-to-volume ratio will be the same for the two bolts. Therefore, the densities will be the same even though the volume changed.

Volume can affect the density of a hollow object. This is because hollow things may be squeezed into a smaller space. For example, a sponge cake can be squished so its volume is smaller. But the mass of the cake stays the same. Therefore, the squished cake will have a larger mass-to-volume ratio and a larger density than the original sponge cake.

3. **Textbook questions from "What Did You Find Out?" on page 61:**

The amount of water in the Cartesian diver increases when the bottle is squeezed and decreases when the bottle is released. This changes the diver's average density, causing it to move up or down or float at different levels.

4. A ship made of steel can float because its average density is less than the density of water. A ship is a thin layer of steel that is wrapped around a large volume of air. As you load a ship, denser materials displace the air. The average density of the ship increases. If too much material is loaded onto the ship, its average density will exceed the density of water and the ship will sink.

5. In glycerol the block of wood would float higher because glycerol is denser than water. There are more particles pushing up per unit of surface area in glycerol—therefore, there is a higher buoyant force.

6. **a.** A swim bladder or an air bladder in a fish is similar to a submarine's ballast tank.
   b. increase, less
   c. buoyant force
   d. less than

9. An object should only sink in fluids with a density greater than the average density of the object itself. A sample answer is provided for two objects.

Floating or Sinking				
Fluid	Fluid Density (g/mL)	Float or Sink Behaviour (f/s)		
		Object 1	Object 2	Object 3
		Object 1 Average Density = 0.8 g/cm³	Object 2 Average Density = 9 g/cm³	Object 3 Average Density = ___ g/cm³
helium	0.002	s	s	
ethyl alcohol	0.79	s	s	
machine oil	0.90	f	s	
water	1.00	f	s	
seawater	1.03	f	s	
glycerol	1.26	f	s	
mercury	13.55	f	f	

10. a. You will use the following calculation to determine the answer.

820 mL – 500 mL = 320 mL

The volume of the hand is approximately 320 cm^3. **Note:** The volume can only be approximated. If you read the volume of the water and hand to be as low as 810 mL, you should consider yourself to be correct. The calculation of the answer would then be 310 mL.

b. You used the displacement technique.

11. Textbook question, "Pause and Reflect," page 67:

Water solutions contain particles of solute. The density of a water solution depends on the density of the solute. If the solute is denser than water, the solution will also be denser. If the solute is less dense than water, the solution will also be less dense. Dense substances have more particle-per-unit volume than less-dense substances.

Section 2: Review

Textbook questions 2 to 8 from "Wrap-up: Topics 4 to 6," page 70:

2. Factors that affect the internal friction of a fluid include

- the size of the fluid particles
- the shape of the fluid particles
- the temperature of the fluid

3. Answers will vary but could include any three of the following:

- maple-sugar production
- the petroleum industry
- motor mechanics
- food processing
- the chemical industry
- the cosmetics industry

4. In a gas the particles are separated from each other and are moving quite fast. Increasing the temperature causes them to move even faster and bump into each other more often. This increases the internal friction and, therefore, the viscosity. Cooling a gas slows the particles and lowers the viscosity.

In liquids the particles are in contact with one another and are quite strongly attracted. Increasing the temperature increases the energy of the particles—this causes them to move faster, hit harder, and move farther apart. This allows the particles to move past each other with less resistance, and it also reduces the viscosity.

5. Generally, a substance in its liquid state is less dense than it is in a solid state and is denser than it is in a gaseous state. Water is the exception to this generalization because solid water is less dense than liquid water—ice floats in liquid water.

6. Measure the volume of the container that holds the gas.

7. Density (g/mL or g/cm^3) $= \dfrac{\text{mass}(\text{g})}{\text{volume}\ (\text{mL or cm}^3)}$

8. The fluid particles exert an upward force on an object. If the particles of the object are more densely packed than the fluid, the object sinks. The object floats if they are less densely packed.

Section 3: Lesson 1

1. Pressure $= \dfrac{\text{Force}}{\text{Area}}$ or $P = \dfrac{F}{A}$

2. **a.** $P = \dfrac{F}{A} = \dfrac{534\ \text{N}}{0.051\ \text{m}^2} = 10\,471 \dfrac{\text{N}}{\text{m}^2} = 10\,471\ \text{Pa} = 10.5\ \text{kPa}$ (rounded to tenths)

   Noriko applies a pressure of 10.5 kPa.

   b. The pressure would increase because the area is decreased.

   $$P = \frac{F}{A} = \frac{534\ \text{N}}{0.014\ \text{m}^2} = 38\,143 \frac{\text{N}}{\text{m}^2} = 38\,143\ \text{Pa} = 38.1\ \text{kPa}$$ (rounded to tenths)

   The pressure will increase to 38.1 kPa.

3. Answers will vary depending on your weight and seating area.

   Suppose you weigh 500 N.

   The force exerted is $500\ \text{N} \times \frac{9}{10} = 450\ \text{N}$.

   Suppose the seating area is 0.18 m^2.

   Then the pressure is as follows:

   $$P = \frac{F}{A}$$
   $$= \frac{450\ \text{N}}{0.18\ \text{m}^2}$$
   $$= 2500\ \text{N/m}^2$$

   The pressure is 2500 N/m^2.

4. Answers will vary depending on your weight and the size of the screwdriver tip.

Assume the weight is 500 N.

Then the force exerted is $500\ \text{N} \times \frac{9}{10} = 450\ \text{N}$.

Assume the screwdriver has a tip area of 0.000 005 m^2.

Then the pressure is as follows:

$$P = \frac{F}{A}$$
$$= \frac{450\ \text{N}}{0.000\ 005\ \text{m}^2}$$
$$= 90\ 000\ 000\ \text{N/m}^2$$

The pressure would be 90 000 000 N/m^2.

5. A designer uses "extra" material to make a large seating area. With a large seating area the weight of a person is spread over a large area. This results in a much smaller and a more comfortable pressure.

6. **a.** A bed of nails made with lots of nails would definitely be more comfortable than one made with only a few nails because Ammar's weight—force—would be distributed over the combined area of the nailpoints, which is a much larger surface area. Because of this the pressure Ammar experienced would be significantly lower.

b. Standing on the nails would be very painful! All Ammar's weight or force would be applied to a very small surface area—the tips of a few nails. This would cause a very high pressure. Lying down would distribute his weight over the greatest surface area, creating the lowest pressure.

7. The space between gas particles is very large. This allows the particles to be pushed together.

8. The particles of a solid are stuck together and are closely spaced. A force applied to one particle is transmitted in a chain-reaction throughout the solid. The particles cannot individually move in the direction of the applied force. If the solid is free to move, the whole solid will move in the direction of the applied force.

9. When your feet hit the ground, the air pockets get squeezed. Some of the impact force is absorbed as the air particles are pushed closer together and then farther apart. This lowers the impact force absorbed by your feet and adds bounce to your steps.

10. The air in a tire is somewhat compressed to provide support for the car's weight, but the air can be further compressed when a tire hits a bump to absorb shock and to make the ride smoother. In the air-bag system a compressed gas, nitrogen, is released to inflate the air bags only when the car hits something with a large force. The bags remain inflated only for a brief moment. While inflated, the air bags cushion the impact of the occupants with the dashboard, the steering wheel, or with other solid parts of the car.

11. Textbook questions 1 and 2 from "What Did You Find Out?" on page 75:

1. The side of the metre-stick attached to the full balloon moves slowly downward as the compressed air escapes from the pierced balloon. Before one of the balloons was punctured, the two balloons were equal in weight or balanced—the force of gravity pulling them down was equal.

2. The gas has volume because the balloon expanded as the gas was blown into the balloons.

   The gas has weight because the balloon balance went down on one side with only one inflated balloon attached. If something has weight, it also has mass. Therefore, the gas has mass. **Note:** This experiment "works" because the air inside a balloon is compressed and slightly more dense than the surrounding air.

12. a. The balloon will expand because the pressure outside the balloon is less. It will expand until the pressure inside the balloon equals the pressure outside. Internal pressure decreases as the particles move farther apart.

b. The balloon will become smaller because the water pressure is greater than the atmospheric pressure. The air in the balloon is compressed until the pressure inside it equals the pressure outside.

13. At first, outside pressure increases but the pressure inside your ear is still at the level it was at the top of the mountain. The thin membrane of the eardrum gets pushed inward as the outside pressure increases. The pressure is balanced on both sides of the eardrum by a burst of air moving through your Eustachian tube into the inner ear. This burst caused a "pop."

14. Textbook questions from "Pause and Reflect," page 76:

When you draw fluid out of a sealed container, the pressure in the container drops. The pressures inside and outside the container are no longer in balance. If the container is made of a flexible material, the higher atmospheric pressure will push the walls of the container in until the internal and external forces are once again balanced. In the case of a glass bottle, the sides are strong enough to resist the atmospheric forces.

17. Textbook questions 2 and 4 from "Topic 7 Review," page 77:

2. **(a)** The pascal (Pa) is the Systems International (SI) unit of pressure, although the larger kilopascal (kPa) is usually used.

   (b) The unit Pa can also be expressed as a newton per square metre (N/m^2).

4. In a fluid at rest a force is exerted equally in all directions.

Section 3: Lesson 2

1. The acronym CFC stands for chlorofluorocarbon.

2. Fluid particles always flow from areas of high pressure to areas of low pressure. Gas compressed into a strong-walled container will exit through small holes with great force. If a liquid is also in the can, the moving gas will push it out as a foam or as a fine spray.

3. **a.** Particles always flow from areas of *high pressure to low pressure*.
   b. Gases under pressure are *ready to expand* because the particles have *so much energy*.
   c. The force of gases under pressure can be used in many ways to *carry, push, or move objects*.

4. Aerosols contain a gas under pressure. A carbon dioxide fire extinguisher contains liquid carbon dioxide. Carbon dioxide can be liquefied by cooling it to very low temperatures. High pressure in the fire-extinguisher tank keeps it liquefied. When the carbon dioxide is released from the tank, the carbon-dioxide particles gain energy from their surroundings and turn into a gaseous state. The carbon-dioxide gas is very cold and extinguishes the fire by cooling and cutting off the oxygen supply—CO_2 is heavier than air and does not burn.

6. **Textbook questions 1 and 2 from "What Did You Find Out?" on page 80:**

   1. Applying a force at the main cylinder in a hydraulic system causes the reacting plunger to move out, because the force is transmitted throughout the enclosed liquid. In order for one particle to move, the one in front of it must move. And for the second one to move, the particle in front of it must move. And so on. In other words all of the fluid particles move.

   2. The hydraulic system would work the same over longer distances because the force would still be transferred. To test this, various lengths of tubing can be connected between the syringes.

7. **a.** It took less force to push the little plunger than it did to push the big one.

   b. The little plunger always travelled farther than the big one.

   c. Even less force would be required to push the little plunger. More force would be required to push the big plunger. The distance the large plunger moves would be even less.

   d. "Real-life" applications include hydraulic systems on tractors, garbage trucks, front-end loaders, and hydraulic lifts in garages.

8. **a.** $P = \frac{F}{A} = \frac{100\ \text{N}}{1\ \text{m}^2} = 100\ \text{N/m}^2 = 100\ \text{Pa}$

   The pressure is 100 Pa.

   b. $F = P \times A$

   $= 100\ \text{N/m}^2 \times 2\ \text{m}^2$

   $= 200\ \text{N}$

   You could lift a load of 200 N.

   c. Since the large plunger has twice the area, it will travel half the distance— 0.40 m.

9. **a.** In a pipeline that transports fluids, pumps are used to maintain pressure.
   b. It takes one week to transport a sample of natural gas from Alberta to Ontario.

10. A compressor is used to pressurize a pneumatic system.

11. Examples of pneumatic systems include gravel tampers, dentist drills, and pneumatic or air brakes.

12. **a.** A small rise was observed.
b. The system is a pneumatic system.

13. **a.** Yes, the book did rise.

b. The system is a hydraulic system.

c. The hydraulic system raised the book higher because the liquid was not compressed by the weight of the book.

14. **Textbook questions 1 and 3 from "Topic 8 Review," page 84:**

1. A hydraulic system is a device that transmits an applied force through a liquid to move something else.

The following are examples of hydraulic systems:

- an automotive lift
- hydraulic systems on construction and farming equipment
- your circulatory system
- a water pistol
- a tap-water system

3. Bends and dirt in a pipeline increase friction, which leads to a loss in pressure. This requires the pumps to work harder and makes the operation more expensive.

Section Review

Textbook questions 1, 3, and 8 from "Wrap-Up: Topics 7 to 8," page 85:

1. **(a)** False. Pressure equals force divided by area.
(b) True.
(c) False. Altitude and depth can affect fluid pressure.
(d) False. Hydraulic systems depend on liquid pressure.
(e) True.
(f) False. A dentist's chair is an example of a hydraulic system.
(g) True.
(h) False. An air bag uses compressed gas—pneumatics.
(i) True.
(j) False. Liquid must be enclosed.

3. The particles of gases are far apart and can easily be pushed together into a smaller volume.

The particles of liquids and solids are already close together. The particles of solids are even fixed into place. Therefore, liquids and solids are incompressible.

8. As the helium balloon rises the atmospheric pressure outside the balloon decreases. The balloon will increase in volume—equalizing internal and external pressure—until it finally can stretch no more and bursts.

Module Review

Textbook questions 1 to 5, 10, 12, 15, 16, 21, 27, 29, 34, and 37 from "Unit 1 Review," pages 90 to 93:

1. **(a)** Answers will vary but could include

- a concrete, sand, and water mixture
- an Italian salad dressing
- rocks
- an oil spill on the water

(b) Answers will vary but could include the following:

- apple juice
- vinegar
- sugar water

(c) Answer will vary but could include milk, jelly, and butter, which all appear homogeneous but are, in fact, heterogeneous.

2. A mixture is matter that consists of two or more substances—individual properties may combine. Possible examples are chocolate-chip cookies, tea, and gum.

A pure substance is matter that consists of only one kind of particle. Possible examples include gold, oxygen, salt, and sugar.

3. Possible examples include the following.

Solution Components		
Solution	**Solvent**	**Solute**
musk perfume	**oil**	**scent particles**
air	**nitrogen**	**oxygen, carbon dioxide**
soft drink	**water**	**flavouring, colour, sugar**
rubbing alcohol	**alcohol**	**water**
brass	**copper**	**zinc**

4. The sugar particles are more strongly attracted to the water particles than they are to each other. As a result, the sugar particles break away from each other and diffuse into the spaces between the water particles. Sugar particles are more attracted to each other than they are to oil, so they remain clumped in oil—they don't dissolve.

5. A hot solvent will usually hold more solute than when it is cold because the spaces between the particles are larger. The heat energy also aids faster dissolving because the particles are moving faster.

10. Particles in solids are held in place by strong attractive forces between particles. Fluid particles are free to move out of the way when an object applies a force or weight to them.

12. **(a)** Allow the mixture to separate into layers; then skim or pour the oil off the top. Boil the mixture and the water will evaporate. Freeze the water and pour off the oil.

(b) Sort the objects by hand according to colour, lustre, and shape. A magnet will attract the paper clips if they are made with iron.

(c) Add water to the mixture. The sugar will dissolve and the sawdust will float on the surface. Remove the sawdust by filtration and recover the sugar through evaporation.

15. Boil, distill, or evaporate a certain amount of each sample. The water sample that leaves more residue is the ocean water.

16. Add more salt to the sample. If it dissolves the water is not yet saturated.

21. **(a)** Material 1 has the largest mass when the volume is 50 cm^3.

(b) Material 3 has the largest volume—40 cm^3—at 100 g.

(c) The slope of each graph corresponds to the mass-to-volume ratio.

Material 1 has a mass-to-volume ratio of 11.3 g/cm^3.
Material 2 has a mass-to-volume ratio of 8.0 g/cm^3.
Material 3 has a mass-to-volume ratio of 2.5 g/cm^3.

Note: The values for the ratios you found correspond to the densities of the materials.

27. A high-viscosity milkshake would likely require a short, straight, large-diameter straw. You need to consider factors like

- smoothness
- the size of the ice crystals
- the presence of chunks—fruit, chocolate, nuts
- the rate of melting
- the material the straw is made from—strength, rigidity, reaction to cold
- the length, shape, and diameter of the straw

29. The boat would sink because the weight of the water it displaces is less than the boat's weight.

34. Normally, drinking water is not pure. Drinking water contains dissolved substances, gases, and minerals. These dissolved substances give drinking water its taste. Water from different sources may contain different kinds and amounts of solutes.

37. You can think of an iceberg as a giant ice cube. Because the iceberg is floating in saltwater, which is denser than freshwater, the iceberg will float a bit higher. In other words, it will float with more of its ice above the water surface. That leaves less ice below the water surface. The result is that the iceberg floats with a bit less than nine-tenths of its mass below the water surface.

Image Credits

Cover
PhotoDisc Collection/Getty Images

Welcome Page
PhotoDisc Collection/Getty Images

Contents Pages
PhotoDisc Collection/Getty Images

Appendix Cover
PhotoDisc Collection/Getty Images

Page

11 PhotoDisc Collection/Getty Images
12 **bottom:** PhotoDisc Collection/Getty Images
13 **middle:** PhotoDisc Collection/Getty Images
bottom: © 2002–2003 www.clipart.com
14 PhotoDisc Collection/Getty Images
17 **top:** PhotoDisc Collection/Getty Images
bottom: Corel Corporation
21 PhotoDisc Collection/Getty Images
24 PhotoDisc Collection/Getty Images
25 **top:** © 2002–2003 www.clipart.com
28 PhotoDisc Collection/Getty Images
30 EyeWire Collection/Getty Images
31 **middle left and bottom:**
PhotoDisc Collection/Getty Images
middle right: © 2002–2003 www.clipart.com
33 © 2002–2003 www.clipart.com
43 PhotoDisc Collection/Getty Images
45 Corel Corporation
47 EyeWire Collection/Getty Images
53 PhotoDisc Collection/Getty Images
54 PhotoDisc Collection/Getty Images
55 **bottom:** PhotoDisc Collection/Getty Images
59 PhotoDisc Collection/Getty Images
63 PhotoDisc Collection/Getty Images
65 Corbis
66 PhotoDisc Collection/Getty Images
68 Corel Corporation
73 **top:** PhotoDisc Collection/Getty Images
81 EyeWire Collection/Getty Images
83 EyeWire Collection/Getty Images

© 2003